AN EXPERIMENTAL INVESTIGATION OF THE FORM OF INFORMATION PRESENTATION, PSYCHOLOGICAL TYPE OF THE USER, AND PERFORMANCE WITHIN THE CONTEXT OF A MANAGEMENT INFORMATION SYSTEM

BY

DONALD L. DAVIS

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1980

TO DONNA, DONNIE, AND MARK

ACKNOWLEDGEMENTS

I wish to express my gratitude to my dissertation advisor, Dr. Richard A. Elnicki, and to the rest of my committee, Dr. Roger W. Elliott, Dr. H. Russell Fogler, Dr. William M. Fox, and Dr. Marvin E. Shaw. They provided invaluable assistance and encouragement throughout the course of this effort. Also, I wish to express my gratitude to my friend and colleague, William A. Shrode, who provided so much aid and encouragement during some rather trying times.

A special debt of gratitude is owed to my wife, Donna, my sons, Donnie and Mark, and my mother and father, Mr. and Mrs. Lester Tesch, for their encouragement and sacrifice in the pursuit of our goal. It was not in vain.

TABLE OF CONTENTS

LIST OF TABLES

Abstract of Dissertation Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

AN EXPERIMENTAL INVESTIGATION OF THE FORM OF INFORMATION PRESENTATION, PSYCHOLOGICAL TYPE OF THE USER, AND PERFORMANCE WITHIN THE CONTEXT OF A MANAGEMENT INFORMATION SYSTEM

By

DONALD L. DAVIS

March 1981

Chairman: Richard A. Elnicki
Major Department: Management and Administrative Sciences

This study examined the effects of the psychological type of a user and the report type provided a user of a management information system (MIS), on user performance. An experimental model for user performance involving three dependent variables (cost of production, decision time, and level of confidence) and three independent variables (psychological type of the user, the production environment, and report type) was used in the study. The model was used to examine the effects on performance by four different report types and four different psychological types of production managers.

The four report types involved the combination of two different formats (tabular versus graphical), and two different levels of summarization (statistically summarized versus raw data). The psychological type of the user was determined by combining perception and evaluation modes obtained by the user from application of the Myers-Briggs typing instrument. Thus, a user had a psychological type of sensing-thinking, intuitive-thinking, sensing-feeling, or intuitive-feeling.

The experiment was conducted using ninety-six MBA students as subjects in a computer-simulated production environment. Each subject was randomly assigned to a treatment group. The subjects assumed the role of a production manager, made decisions for levels of production for the simulated company using reports generated by the simulator, and received reports concerning the outcomes of their decisions, on which they based future decisions. The objective of the simulation was to obtain a minimum cost for a simulated year of production.

Multivariate and univariate analysis of the experimental data provided evidence of significant results due to the experimental treatments. The results suggest important implications for future MIS design and for selection of production managers in existing MIS environments, given that the experimental results hold within an actual production environment.

In the area of future MIS design, results indicated that if an organization has no knowledge of the cognitive type of report users, the best reports to offer in the production environment are the tabular-raw data or graphical-raw data reports. Where the cognitive type of the user is known, the MIS design should offer graphical-raw data reports to sensing-thinking users, tabular-raw data or tabular-statistically summarized reports to sensing-feeling users, tabular-raw data or graphical-statistically summarized data reports to intuitive-feeling users, and any of the four report types to intuitive-thinking users.

Given an existing MIS design, experimental results suggest that a firm dominated by a tabular-raw data report structure should give preference to sensing-feeling or intuitive-feeling types for production managers. An organization with a graphical-raw data dominated report structure should give preference to sensing-thinking, sensing-feeling, or intuitive-feeling types for production managers. For a firm whose report structure is primarily graphical-statistically summarized data, intuitive-feeling types should be given preference as production managers. Sensing-feeling types should be given preference for production manager in firms whose report structure is dominated by tabular-statistically summarized data reports. The results also suggest that intuitive-thinking types are incompatible with the production environment.

CHAPTER 1

RESEARCH BACKGROUND

Introduction

The proliferation of management information systems (MIS), along with the many disappointments associated with those systems, has generated an ever-increasing interest in research in the area. The dissatisfaction expressed by MIS users [6, p. 1335] may be partially attributed to the confusion concerning just what an MIS is. Small and Lee state that "the elusiveness of most MIS definitions leads naturally to vague understanding and to elusive promises [33, p. 49]. Simon leaves no doubt that a definitional problem exists, "There is no agreement on the term management information system" [32, p. 126]. The lack of agreement on what is contained in an MIS has hampered research in the MIS area [8, p. 14]. Many definitions are too general for use in MIS research or in MIS design. As an example, Pokempner considers an MIS to be "the most highly formalized of the many procedures in business and government by which data are transformed into information" [27, p. 45]. One MIS advocate, Bishop Walton, solved the definitional problem by the following statement: "It is almost impossible to define an information system, but it is easy to recognize one" [15, p. 66].

The definition followed in this study was proposed by Small and Lee [33]. They define an MIS as "a system for providing information for management" [33, p. 50] where

> a system implies order, arrangement, and purpose. Information should be distinguished from data. Data are raw facts in isolation and do not become information until someone has a need to know and utilizes the data to become informed. [33, p. 50]

This definition is general enough to include all design aspects of MIS and yet is restrictive enough to be operational.

A primary source of dissatisfaction with information systems is that many have been designed to suit the psychology or decision-making style of the analyst/designer, not that of the user of the system [2, 11, 12, 29]. This fact led Mason and Mitroff to propose the following as one of their principles to guide MIS researchers:

> Managers need "information" that is geared for THEIR psychology and NOT to that of their designers . . . they must not only find out what information the manager actually needs (as Ackoff [2] points out, this is often far removed from what they think they need), but the designers must also find out which mode of displaying the information is most amenable to the manager's psychology. [23, p. 485]

The psychology of the manager referred to by Mason and Mitroff in the above quote is characterized by the Jungian typology [26, p. 485] and implemented by the Myers-Briggs Type indicator [26]. The decision maker processes information by perception and evaluation. The indicator presents two modes of perceiving and two modes of evaluating what has been perceived [26, p. 1]. The two modes

for perceiving are sensation and intuition. Sensation is perceived by use of the five senses [26, p. 1]. Intuition is an "indirect perception by way of the unconscious, accompanied by ideas or associations which the unconscious tacks on to the perception from the outside." [26, p. 51].

The two modes for the evaluation process are thinking and feeling [26, p. 52]. Thinking is a logical process. It is impersonal and rational in nature [26, p. 52]. Feeling is a process of appreciation, subjective in nature [26, p. 52].

Mason and Mitroff extended their argument for research on both the presentation of information and the psychological type of the user:

> What is information for one type (person) will definitely not be information for another. Thus, as designers of MIS, our job is not to get (or force) all types to conform to one, but to give each type the kind of information he is psychologically attuned to and will use most effectively. [23, p. 478]

The view that the psychological type of the user should be used in MIS experimentation is reinforced by Benbasat and Schroeder:

> Experiments should be designed to include both human and MIS design variables. Most MIS theoretical frameworks recognize the central importance of the business decision maker as a determinant of the type of information needed. Future work should focus on instruments to describe human characteristics and on incorporating these characteristics into research designs. [4, p. 47]

Another advocate of matching reports to the user's needs is Radford:

> The degree to which output of the information system meets a manager's needs for support in decision making depends on two factors: (a) the nature and form of the information presented and (b) the human capability for absorbing, processing, and using information. The characteristics of the human information processing system must, therefore, be taken into account when making decisions regarding the form of the output from the organizational system. Lack of attention to this requirement may result in the output of the organizational system being unacceptable or less valuable to the managers concerned. [28, p. 17]

Literature Review

Much of the empirical research on this subject in the recent past was done by members of the University of Minnesota's MIS department and is appropriately called "The Minnesota Experiments" [10].

The Minnesota Experiments

The Minnesota Experiments focused on the relationship between decision activities and information system structure. A major contribution from and an integral part of all the experiments was the descriptive model developed by Dickson, Chervany, and Kozar [9, p. 21] which relates MIS variables to user performance. The model considers user performance (P) (measured by total cost under the user's control, time taken to make a decision, or other measures depending on the decision environment and other variables in the model) to be affected by the environment of the decision maker (DE), the personal characteristics of the decision maker (DM), and the characteristics of the information system (CIS). The decision environment variable (DE) is comprised of functional area (i.e., finance

production, marketing, personnel, research and development), organizational level (i.e., strategic, tactical, operational), and the environmental measures (i.e., stability, competitiveness, and time pressure). The decision maker variable (DM) consists of cognitive style and other directly and indirectly acquired attributes such as aptitudes and attitudes of the decision maker. The characteristics of the information system variable (CIS) is composed of the form, content, level of summarization, presentation media, time availability, and decision aids (i.e., prediction equations, EOQ models, etc.) [10, p. 918]. In functional form, the model is expressed as:

$$P = f(DE, DM, CIS)$$

The series of experiments began with a study by Chervany and Dickson [6] of the effects of two different forms of information presentation on performance in a production environment. The other experiments in the series were based on that original study using the Dickson et al. model and the technique of experimental gaming with a computer-based simulator to create an artificial decision-making environment. Experimental gaming involves the interaction of the subjects with a computer program which simluates the decision environment. The subjects act as decision makers, use their decisions as inputs to the program, and receive as outputs the simulated results of their decisions in the form of reports [6, p. 1336].

One of the Minnesota experiments [6] was concerned with the CIS variable alone, while four [3, 4, 20, 30] involved the DM and CIS variables. All five impinge on the proposed study and are discussed below.

Chervany and Dickson [6] used 22 MBA students as subjects to study the effects of varying the level of summarization of a report on performance. Subjects were paired by ATGSB (Aptitude Test for Graduate Study in Business) scores and randomly assigned to a report set. Subjects were provided with either a statistically summarized production report or a raw data (detailed) production report set (CIS). The subjects used the reports to reach decisions for simulated production runs. Three practice runs and ten actual runs were made and therefore a total of ten decisions was made by each subject. For each run, each subject also gave a level of confidence (1-10) for the decision and the time necessary to make the decision. Performance was primarily measured by the total cost (hire/fire costs + raw material costs + inventory costs) incurred in the simulated production runs, but deicision time and confidence level were used as well. The results of the study indicated that subjects with summarized data reports performed better, but had higher decision times and lower confidence in their decisions than those subjects receiving raw data reports. However, the results were not significant.

Barkin and Dickson [3] used undergraduate business students as subjects to study the effects of cognitive style and the effect of ordering of relevant and irrelevant reports on using information. Cognitive style (DM) was depicted as analytic versus heuristic, based on a 17-question instrument titled WCFAFT 3.2. The sample consisted of 11 heuristics and 15 analytics. The subjects received summarized production reports (CIS) with 198 information elements, 87 judged critical to the production decision by experts and 111 judged noncritical. There was no measure of performance. Subjects highlighted the information items used by them in reaching a decision. The results of the study were that heuristics tended to select more information items than did analytics. As well, heuristics tended to select more irrelevant items overall.

Benbasat and Schroeder [4] conducted an experiment to study the effects of cognitive style (DM), format (CIS), number of reports available (CIS), and knowledge of functional area (DM) on performance. Subjects were classified as analytic or heuristic using the WCFAFT 3.2. Reports were generated by a production simulator with ten runs as in the Dickson and Chervany study [6], but the format, rather than the level of summarization, was varied. Reports were either tabular or graphical. Decision-making aids in the form of forecasts and EOQ models were available. Exception reports were available to a treatment group on a ten-percent change in the mean of an information item. One group had a total of eight

"necessary" reports available, while another group had eleven additional reports available on request. Subjects were classified as high or low knowledge on the basis of a fourteen-item test concerning production knowledge. Performance was measured primarily by cost (ordering + carrying + stockout + unit production cost), but also included decision time and number of reports requested.

Thirty-two subjects were assigned among treatment groups on the basis of their decision-making style and functional area knowledge level. Incentive was increased by a monetary award. The subjects were undergraduate students in a production course.

Two main effects significantly affected cost--format and decision aids. Subjects receiving graphical reports did better than those receiving tabular reports. Subjects receiving decision aids did better than those without decision aids. Subjects using decision aids took longer times to make decisions. At the interactive level, subjects who had neither graphical reports nor decision aids incurred the largest cost. Decision-making style as measured by the WCFAFT 3.2 had no significant effect on performance. As well, the number of reports available had no significant effect on performance.

Senn and Dickson [30] conducted an experiment involving procurement decisions (DE) with purchasing managers from large versus small organizations as subjects (DM). A simulated gaming environment was used, as in all the

"Minnesota Experiments". Paper versus CRT (cathode ray tube) reports (CIS), summary versus detailed reports (CIS) were used as treatments. This experiment was a replication of previous experiments, but in a different decision environment with actual rather than surrogate subjects. Performance was measured on cost (hire/fire costs + raw material costs + inventory costs), decision confidence, and time.

The subjects received either a detailed output from a line printer, a summarized output from a line printer, or a summarized output on a CRT terminal. Results indicated that no significant relation existed between organization size and performance levels. However, CRT users made faster decisions and requested fewer reports. There was no significant difference in total cost performance between groups receiving summary and detailed reports.

Another study involving DM and CIS variables was conducted by Kozar [20]. The subjects were MBA students. The study was primarily designed to build on the Chervany and Dickson study [6] and determine the effects of media (CIS) and quantitative ability (DM) (as measured by the Aptitude Test for Graduate Study in Business) in performance measured by cost (hire/fire costs + raw material costs + inventory costs), decision time, and confidence.

Subjects received statistically summarized reports from a line printer or a CRT. The only significant result was that CRT users had longer decision times than paper

report users. Quantitative ability had no effect on performance. There was no significant difference found for cost performance or decision confidence.

Other Studies

A study using a modified version of the Dickson et al. model was conducted by Amador [1]. In his study, Amador considered the effects of ordering of information items (CIS), graphical versus tabular format (CIS), point estimates versus interval estimates (CIS), and the number of decision entities (CIS), where decision entities refers to "the separate pieces of information present on a report and on which decisions are required" [1, p. 26] on performance. Performance was measured by cost, decision time, and choice behavior (i.e., the number of checks performed by a subject). A computer simulation program was used for the experiment. One hundred and sixty undergraduate students who had completed their first undergraduate statistics course were the subjects for the experiment. The subjects were randomly assigned to each of the sixteen treatment groups, i.e., four factors of two levels each.

The experiment consisted of a subject's using a report to predict the occurrence of certain events. The subject was given an opportunity to check via the simulator to determine if the event had occurred. The event could be "detected" only if the check was made on the simulated day of occurrence. If the event was not detected, a cost of five dollars was assessed. Each check cost the subject one dollar. The objective for a subject was to minimize the

total cost of checking for the occurrence of the event and missing the occurrence of the event itself.

Results indicated that ordering of information items affected all three performance measures jointly. Tabular versus graphical data also affected all three performance measures jointly. Also, subjects with graphical reports made more checks than those with tabular reports. Subjects with the more convenient ordering of information items had significantly shorter decision times. Subjects with a "high density of decision entities" report were more sensitive to report format differences than those subjects with "low density of decision entities" reports.

The first significant field study was performed by Lucas [21] using a descriptive model he had developed to study the effects of several classes of MIS variables on a user's performance. Lucas's model was unique, since it provided for the feedback of user performance to be used in evaluating the effect of previous user performance on the use of the information system by the user. The variables included in Lucas's model are essentially the same as those in the Dickson et al. model.

Lucas's model considers performance to be a function of action, analysis, personal and decision-style variables (primarily DM in the Dickson et al. model), the quality of the information systems (CIS in the Dickson et al. model), and the situational factors (DE in the Dickson et al. model). Further, Lucas argues that the performance

of the user is affected by the manner in which he uses the information system (U). Continuing with Dickson et al. variables for consistency in functional terms, Lucas's model is expressed as

$$P = f(DE, DM^*, CIS)$$

where DM* consists of characteristics of the decision maker in the Dickson et al. model plus the manner in which the user uses the information system.

In a test of the model, Lucas conducted a field study in an organization with a computerized information system. Using salesmen as his subjects and their total dollar bookings as the measure of performance, Lucas's results, in general, conformed to those of the Minnesota experiments. Further, his results showed that when relevant information is provided and used, increased usage of the system increases performance. On the other hand, when the information provided is irrelevant to the decisions that must be made, performance is negatively affected by increasing the usage. One of the most important implications of the study, according to Lucas, was that different personal, situational, and decision style variables (DM*) appeared to affect the use of the system. This is another indication that the psychological type of the user should play a role in the design of a system.

Lusk and Kersnick [22] report a study involving the effects of report format (CIS), level of summarization (CIS), user perception (DM), and report complexity (DM)

on performance. Report format was at two levels, tabular and graphical, while the level of summarization was at three levels -- raw data, cumulative frequencies, and percentages. User perception was determined by a score on the Embedded Figures Test (EFT), whereby subjects were classified as high analytic or low analytic. Performance was determined by the number of correct answers to a twenty-question instrument involving simple arithmetic. The answers were derived by the subject using information from one of the experimental reports. An example of the questions is as follows: "How many of all professional sampled were accountants who earned $20,000 or less?" [22, p. 790] Subjects were 219 undergraduate students. No information was given on the class level of the students. The EFT was administered to the subjects as they met for their regular classes. Each subject was given all of the following types of reports to rank for complexity: tabular-raw data, tabular-percentages, graphical (frequency histogram)-raw data, graphical (cumulative frequency)-raw data, graphical (cumulative frequency)-percentage. In a second session one week after the first, subjects were given a particular report type and the twenty-question test. Although the authors did not comment on the possible effect, the test was time constrained. Monetary prizes of $10 and $5 were given for best performances.

The results showed no significant effect due to psychological type. Tabular reports were perceived as less complex by the subjects and resulted in the best performances.

Jungian Studies

Some studies have used the Jungian psychology of types [18], as implemented by the Myers-Briggs typing instrument, to study the effect of cognitive type. The indicator following the Jungian typology presents two modes of perceiving and two modes of evaluating what has been perceived [26, p. 1].

As described earlier in this chapter, the two modes for perceiving are sensation and intuition [26, p. 51]. Sensation is perceiving primarily by use of the five senses [26, p. 51]. Intuition, on the other hand, is an "indirect perception by way of the unconscious, accompanied by ideas or associations which the unconscious tacks on to perception from the outside" [26, p. 51]. The appendages by the unconscious can range from the simplest hunch to the scientific discovery. The individual who is a sensation type prefers detail and objective hard facts, while the intuitive type prefers possibilities and totality or Gestalt in the perception process [26, p. 56].

The two modes for the evaluation process are thinking and feeling [26, p. 52]. Thinking is a logical process. It is impersonal and rational in nature [26, p. 52]. Feeling, in contrast, is a process of appreciation, subjective in nature [26, p. 52]. The thinking type is characterized by abstract true/false judgement, while the feeling type is characterized by evaluations in the good/bad, pleasant/unpleasant vein [26, p. 52]. The modes

tend to be mutually exclusive, and the two modes for perception are independent of the two modes of evaluation [26, p. 53]. Thus, the four modes can be partitioned into psycholocial types [26, p. 53]. The four levels of the psychological-type variables are [26, p. 53]:

1. Sensation-Thinking (ST)
2. Sensation-Feeling (SF)
3. Intuition-Thinking (IT)
4. Intuition-Feeling (IF)

This instrument has been used extensively in many fields. Furthermore, it has come to be used by researchers investigating managerial behavior. McKenney and Keen [24] used the Myers-Briggs instrument to type managerial decision-making styles, as did Hellriegel and Slocum [17], Smith and Urban [34], and Mitroff and Kilmann [25].

McKenney and Keen's study [24], although not primarily concerned with MIS's, examined the cognitive process involved with the information processing and decision making by managers.

They developed a model of cognitive style with two dimensions, information gathering and information evaluation [24, p. 80-81]. Information gathering is a perceptual process involving the inputing, filtering, and categorizing of information [24, p. 80]. Information evaluation refers to the process of problem solving [24, p. 81]. Information gathering is further divided into two separate and independent classifications, perceptive and receptive [24, p. 80]. "Perceptive individuals bring to bear concepts to filter data; they focus on relationships between items and look

for deviations from or conformities with their expectations" [24, p. 80]. Receptive individuals are "more sensitive to the stimulus itself. They focus on detail rather than on relationships and try to derive the attributes of the information from direct examination of it instead of fitting it to their precepts" [24, p. 80].

Information evaluation is also divided into two classifications, systematic and intuitive. Systematics "tend to approach a problem by structuring it in terms of some method which, if followed through, leads to a likely solution." [24, p. 81] Intuitives "usually avoid committing themselves in this way. Their strategy is more one of solution-testing and trial-and-error. They are much more willing to jump from one method to another, to discard information, and to be sensitive to cues that they may not be able to identify verbally." [24, p. 81].

McKenney and Keen reported the results of three studies conducted using their model [24]. In the first study, twenty MBA students, previously tested and showing strong cognitive styles, participated in a study that made use of a "cafeteria" set of 16 problems [24, p. 84]. The subjects chose any five problems to answer and were invited, but not required, to describe their actions while involved in the solution. Results indicated that systematics developed algorithms or methods to solve the problems, while intuitives attacked the problems and tried something to see where it led them [24, p. 84]. The method of the

intuitive "generally showed a pattern of rapid solution, abandoning lines of exploration that did not seem profitable" [24, p. 84]. Further, "systematics preferred program-type problems, while intuitives like open-ended ones" [24, p. 84].

In another study with the same subjects, McKenney and Keen compared the results of their first study with Myers-Briggs scales [24, p. 84]. A significant relationship was found between the McKenney and Keen model and that of the Myers-Briggs. The strongest relationships were found between Jungian thinking types and McKenney and Keen systematics, and between Jungian feeling types and McKenney and Keen intuitives [24, p. 84].

The third study by McKenney and Keen used eighty-four MBA students as subjects in examining the relationship between cognitive style and career choice. The career preferences between systematic and intuitive subjects were compared [24, p. 85]. Results indicated that systematic students preferred administrative, military, production, planning, control, and supervisory careers, while intuitives were oriented toward careers in psychology, advertising, library science, teaching, and the arts [24, p. 85].

Mitroff and Kilmann use the four Jungian psychological types to describe four forms of management science [25]. The sensation-thinking (ST) form emphasizes precision, control, specific, impersonal analysis and logic, i.e.,

quantitative analysis [25, p. 19]. The intuitive-thinking form of management science (IT), on the other hand, stresses conceptual analysis, a qualitative type of analysis [25, p. 19]. The two other Jungian types of management science are qualitative as well but are slightly different [25, p. 20].

Both the intuitive-feeling (IF) and the sensation-feeling (SF) types rely on subjective and value criteria for analysis rather than on impersonal, logical roles [25, p. 20]. "Rather than attempting to find the common theme or character of some set of phenomena, the feeling function strives to generate differences [25, p. 20]. The major difference between the IF and SF types of management science approach is that SF types strive for some precision while IF's can be abstract and loosely defined [25, p. 20].

To support their classifications, Mitroff and Kilmann describe a study which explores "whether individuals with different psychological types do in fact have different views of organizational design and what constitutes an ideal organization" [25, p. 20].

Three different groups of managers were classified according to their psychological types. The subjects were then asked to write a short story expressing their concept of an ideal organization. Upon completion of the story, each subject was placed in a discussion group based on psychological type. Each group was told to organize themselves as they saw fit, consider the story of each subject

in the group, and then compose a group story which best expressed the groups concept of an ideal organization [25, p. 21].

Each group of managers was tested separately. One group consisted of 25 middle-to-high level managers of business organizations in the Pittsburgh, Pennsylvania, area [25, p. 22]. The other two groups were middle level supervisors in the Pennsylvania State Department of Public Assistance [25, p. 22].

Results indicate that

(1) There is a remarkable and very strong similarity between the stories of those individuals who have the same personality type (e.g., ST)

(2) There is a remarkable and very strong difference between stories of the four personality types [24, p. 21]

Hellriegel and Slocum [17] developed a composite model of managerial decision-making styles based on the Jungian psychology of types. According to this mode, SF managers

> are interested in facts that can be collected and verified directly by the senses. They approach these facts with personal and human concern because they are more interested in facts about people than about things. When asked to write a paragraph or two on their perception of an ideal organization, these individuals often describe an organization with a well defined hierarchy and set of rules that exist for the benefit of members and society. The ideal organization would also satisfy member needs and enable them to communicate openly with one another. [17, p. 35]

While an IF manager would

> rely primarily on intution for purposes of perception and feeling for purposes of decision making. These managers focus on new projects, new approaches, new truths, possible events and the like. They approach these possibilities in terms of meeting or serving the personal and social needs of people in general. Intuitive feeling types avoid specifics and focus instead on broad themes that revolve around the human purposes of organizations, such as serving mankind or the organization's clientele. The ideal organization for these individuals would be decentralized, with flexible and loosely-defined lines of authority and few required rules and standard operating procedures. [17, p. 35]

The ST manager

> emphasizes external factual details and specifics of a problem. The facts of a problem are often analyzed through a logical step-by-step process of reasoning from cause to effect. This manager's problem-solving style tends to be practical and matter-of-fact. When asked to describe his ideal organization, this individual often describes an extreme form of bureaucracy, characterized by its extensive use of rules and regulations, a well-defined heirarchy, emphasis on high control, specificity and certainty, and its concern with realistic, limited and short term goals. [17, p. 35]

The fourth composite, IT managers

> tend to focus on possibilities, but approach them through inpersonal analysis. Rather than dealing with the human element, they consider possibilities which are more often theoretical or technical. These managers are likely to enjoy positions which are loosely defined and require abstract skills, such as long-range planning, marketing research and searching for new goals. The ideal organization for these individuals would be impersonal and conceptual. Goals of the organization should be consistent with environmental needs (such as pure air, clear water and equal opportunity) and the needs of organizational members. However, these issues are considered in an abstract and impersonal frame of reference. [17, p. 35]

One of the most recent studies is that accomplished by Smith and Urban [34]. The study examined the relationship between personality, orientation, measured by the Myers-Briggs Type Indicator, and differences in information processing in an ambiguous and an unambiguous information sequence.

In the study the subjects were grouped by personality type according to Myers-Briggs typing. The groups consisted of 25 sensing-thinking types (ST), 22 sensing-feeling types (SF), 18 intuitive-feeling types (IF), and 15 intuitive-thinking types (IT) randomly assigned to two difference classes. Comparisons were made between the groups in terms of information processing in an ambiguous and unambiguous information sequence. The experiment involved the imaginary drawing of poker chips from bags containing different colors of chips. The subjects were given a sequence of 10 draws, an ambiguous sequence where there was no definite pattern or predominate color and an unambiguous sequence where each successive draw established color pattern. The investigators found that differences in performance on the task was quite siginificant between IT and IF types. Comparisons between the 10 highest thinking and 10 highest feeling types gave significant differences. The same comparisons for the most pronounced sensing and intuition types were also significant.

Summary and Evaluation of Prior Studies

From the foregoing review of pertinent literature, one can see that empirical research in the MIS area is relatively new. The lack of MIS research led to Mason and Mitroff's development of a framework for MIS research and a call for empirical research in the area, to include the psychological type of the decision maker and report construction as design variables [23].

The Minnesota experiments were among the first to use a descriptive model which included the performance of the user of an MIS as the dependent variable while using characteristics of the user and report characteristics as independent variables [10]. The Minnesota experiments were empirical studies relying on a computer program to simulate the pertinent decision environment, generally employing surrogates in the role of decision-makers [3, 4, 5, 9, 10].

The first field study involving actual users of an MIS rather than surrogates as subjects was performed by Lucas. Lucas's descriptive model, basically the same as that used in the Minnesota experiments, added utilization of the system as a factor in user performance and involved salesman as subjects [21].

Results from previous studies concerning the effects of format and level of summarization have been somewhat contradictory. Format has had a significant effect in all the studies mentioned [1, 4, 22]. However, reported results

for effects from level of summarization have been mixed. Amador [1] found significant effects on performance due to the level of summarization, but Chervany and Dickson [6], Senn and Dickson [30], and Lusk and Kersnick [22] did not. Amador's results were found when he considered effects on the performance (dependent) variables jointly, instead of univariate effects on a single independent variable. This may be the key, as Amador argues in his study [1, p. 41].

Three [3, 4, 22] of the previously mentioned studies examined the effect of cognitive type of the decision maker on performance. However, only in the Barkin and Dickson study [3] was there any significant effect reported, and then only in the utilization of the system, not on performance. This seems almost unbelievable to the author, since it appears intuitively obvious that there are different "best" ways of reporting information for managers of different cognitive types, or at least better ways than providing only one type of report for all managers. Further, appeal to experts indicates that there should be better methods of designing information based on the psychological types of managers.

Cognitive type, cognitive style, or psychological type are all terms used interchangeably to refer to "an individual's way of performing 'perceptual and intellectual' activities" [35, p. 90]. Note the two processes contained in the definition. Perceiving and intellectualizing are recognized as two distinct dimensions. Further, in their

information system processing model, McKenney and Keen define cognitive style as "consistent modes of thought" which

> can be classified along two dimensions, information gathering and information evaluation . . . . Information gathering relates to the essentially perceptual process by which the mind organizes the diffuse verbal and visual stimuli it encounters. The resultant "information" is the outcome of a complex coding that is heavily dependent on mental set, memory capacity, and strategies--often unconscious ones--that serve to ease "cognitive strain". Of necessity, information gathering involves rejecting some of the data encountered and summarizing and categorizing the rest . . . . Information evaluation refers to processes commonly classified under problem solving. Individuals differ not only in their methods of gathering data, but also in their sequence of analysis of that data. [24, pp. 80-81]

There are at least two probable reasons for the lack of significant effect due to cognitive type in the reported studies--use of an ineffective instrument for measuring cognitive type, and lack of consideration of the joint effect on correlated dependent variables.

Two of the studies [3, 4] used an instrument, WCFAFT, developed by the MIS Department at the University of Minnesota, to determine psychological type. The instrument has been characterized as measuring only "planned versus spontaneous" preferences in a validity study by Zmud [33]. In that study, WCFAFT and MBTI were administered to forty-eight MBA students. WCFAFT results were compared with MBTI results. WCFAFT correlations with MBTI dimensions were 0.25 for Sensing-Intuition, 0.12 for Thinking-Feeling, 0.06 for Extroversion-Introversion, and 0.78 for Judging-Perceptive [38, p. 1089].

Zmud's results led him to believe that "any MIS cognitive style implications from the Minnesota experiments using WCFAFT should probably not be extended beyond the spontaneous versus planned dichotomy [38, p. 1090]. It is apparent that the types of simulated conditions involved in the Minnesota experiments (Production and Purchasing Simulation) did not lend themselves to discriminating strategy differentiation, and therefore cognitive type, as measured by the WCFAFT, would not be expected to have a significant effect on performance.

Another of the studies used the Embedded Figures Test [22]. This test is a perceptual instrument developed by Witkin et al. [36]. Lusk and Kersnick appeal to an untested suggestion by Witkin et al. [36] that the EFT's dimensions can extend beyond the perceptual process. They extended the measurement to the process of evaluation as well [22, p. 792]. This is stretching the power of suggestion. The appropriate conclusion should have been that the process of perception alone showed no significant effect on performance. In addition, the EFT has been shown to have a sexual bias [37, p. 297]. Lusk and Kersnick did not report consideration of this additional source of variance.

It appears that the two Minnesota studies [3, 4] using cognitive type as an independent variable suffered from the use of a weak instrument to measure the construct, while the Lusk and Kersnick study examined only perception with a somewhat biased instrument. As mentioned previously, Mason

and Mitroff suggest using the Jungian typology operationalized by the Myers-Briggs instrument [26, p. 472].

Validity of the Myers-Briggs Typing Instrument

In the present study, the primary concern with validity of the Myers-Briggs instrument is with the measures of perception and evaluation, i.e., cognitive types. Researchers [19, 23, 25, 34] have been able to use the perception and evaluation of the MBTI because of the results of intercorrelation studies which show perception (SI) and evaluation (TF) to be independent of one another [5, p. 462]. As measured by phi coefficients, the intercorrelations of SI and TF range from -.02 to .07 in three separate studies [5, p. 463].

"The validity of the instrument is dependent on how well it measures what it was intended to measure" [5, p. 467]. Three types of validity have been examined: content validity, construct validity, and predictive validity [5, p. 467].

Content (face) validity is concerned with how adequately the domain of the characteristic is captured by the measure [7, p. 256]. Several investigators have conducted studies on content validity of the Myers-Briggs. These studies have been detailed by Carlyn [5]. The author reported studies in which the item content of the MBTI had been examined. Carlyn concluded that the Sensing-Intuition and Thinking-Feeling scales "seem largely consistent with their corresponding conceptual definitions" [5, p.469].

Predictive validity is concerned with the usefulness of the measuring instrument as a predictor of some other characteristic or behavior [7, p. 256]. Four studies are listed by Carlyn on the predictive validity of the MBTI [5, p. 468]. "The studies . . . suggest that the instrument has moderate predictive validity in certain areas" [5, p. 469].

Construct validity is concerned with what psychological property or properties can explain the variance of the instrument. It is concerned with the relationship between variables [7, p. 258]. As reported by Carlyn, several researchers used factor analysis to investigate the relationship between the constructs measured by MBTI and constructs measured by other instruments such as the Allport-Vernon-Lindzey Study of Values [5, p. 469]. Carlyn concludes that "the numerous studies of construct validity . . . suggest that the individual scales of the Myers-Briggs Type Indicator measure important dimensions of personality which seem to be quite similar to those postulated by Jung" [5, p. 469].

Reporting on the reliability of the MBTI as measured by internal consistency and stability, Carlyn states that internal consistency studies have usually produced acceptable reliabilities, 0.75 to 0.87 to SN and 0.69 to 0.86 for TF, using Cronbach's coefficient Alpha [5, p. 465]. However, studies of stability show some inconsistencies [5, p. 467]. Carlyn suggested that the inconsistencies were functions of age or occupation. Carlyn concluded that "the Indicator

appears to be a reasonably valid instrument which is potentially useful for a variety of purposes" [5, p. 472].

Purpose of the Study

Motivated by the relative scarcity of empirical research dealing with Management Information Systems, by the lack of significant findings, and by conflicting evidence from previous studies on the effects of the cognitive type of the user and report type on user performance, the purpose of the present study is to investigate and evaluate the effects of Jungian Psychological types (ST, SF, IT, and IF) and information presentation (format and level of summarization) on user performance within the context of management information systems. The cost-benefit relationship involved in adapting reports to various psychological types is not considered in the study. The need for the research was detailed earlier [4, 23, 28], along with pertinent research on this area.

Organization of the Dissertation

Chapter 2 contains the research methodology and implications of the results of the study. First, the general model used to guide the study is presented, along with a discussion of the specific methodology used for the study. Next, the three research hypotheses are presented and discussed. Finally, the experimental design for the study is presented, followed by a discussion of research implications.

In Chapter 3, the experimental results of the study are detailed. The implications of the results are discussed in Chapter 4. Also in Chapter 4, the experimental results of this study are compared with the results of previous studies, and the results of the post-experimental questionnaire are discussed.

Chapter 5 is the final chapter of the dissertation. It contains a summary of the study and possible extensions for future research in the area of MIS design.

CHAPTER 2

RESEARCH METHODOLOGY

Introduction

As mentioned in Chapter 1, this study examines the relationship between the psychological type of the user of a report (implemented by the Myers-Briggs instrument), the format of the report, the level of summarization of the report, and their effects on performance (measured by cost, decision time, and level of confidence in the decision). The experiment was guided by a general model based on one developed by Amador [1] from the Dickson *et al.* and Lucas models.

General Model

Amador's model expresses user performance (P) as a function of report format (F) and level of summarization (L), given a particular decision environment (DE), decision maker (DM), and other characteristics of the information system (CIS'). Or, in functional form:

$$P = f(F, L \mid DE, DM, CIS')$$

Therefore, the model used to guide the present study is:

$$P = f(F, L, T \mid DE', DM', CIS')$$

Or, user performance (P) is a function of the report format (F), level of summarization (L), and psychological type of

the user (T), given a production decision environment (DE'), other characteristics of the decision maker (DM'), and other characteristics of the information system (CIS'). Other characteristics of the decision maker (DM') are randomly distributed over the sample population while other characteristics of the decision environment (DE'), and the other characteristics of the information system (CIS') are held constant by the experimental structure and procedures.

Methodology

The experimental gaming methodology used in the Minnesota experiments, as described earlier, was used in the present study. Each subject, classified by psychological type, acted as a production manager. The production simulator is:

> a computer program which simulates the production operations of a manufacturing organization. The program allows one or more users to interact with the simulator, make decisions regarding production, and receive the results of those decisions as though a production cycle had actually taken place. The number of cycles simulated is determined by the user. [9, p. 916]

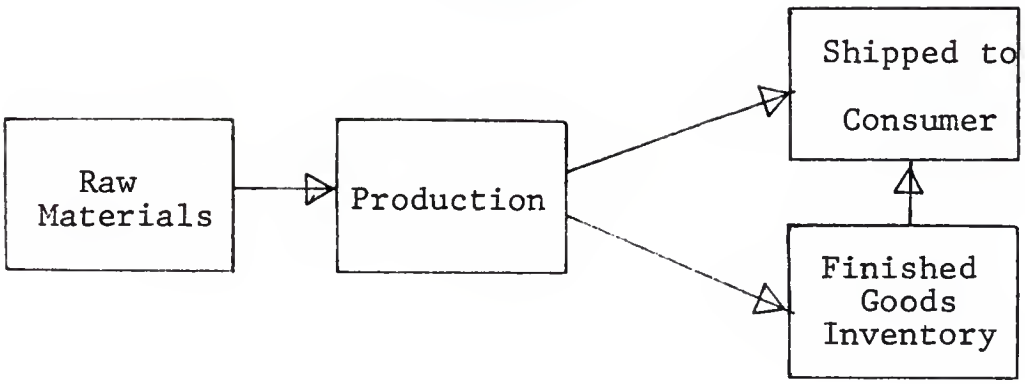
The specific decision environment (DE') is one where the subjects, acting as production managers, make a number of sequential decisions based on reports generated by the productions simulator (CIS'). The production simulator used in this study is entitled SIMPRO.

SIMPRO (Appendix A) is an interactive computer program written in an extended FORTRAN to simulate the production function in a single-product organization. SIMPRO is adapted from UNISIM, a simulation program developed by Roy D. Harris and Michael J. Maggard [16, pp. 197-220].

The purpose of SIMPRO is to allow an individual to assume the role of production manager in a simulated production decision environment. The key tasks faced by the individual assuming the role are as follows.

1. Analysis of the demand faced by the firm.
2. Familiarization with the inventory and production costs experienced by the firm.
3. Development of a production plan for the five-week production period with the objective of minimizing the firm's total costs.
4. The input of production decisions for the weeks production run.
5. Evaluation of the operating results. (To balance production fluctuation, finished goods inventory and stock-out costs.)

The firm produces a single product from raw materials obtained from raw materials inventory. The finished product is either shipped to a customer or placed in finished goods inventory to be shipped at a later date, as shown below.



The following assumptions affect the production system:

1. The firm has an unlimited supply of raw materials.

2. Actual demand for the product averages 100,000 units per week; however, demand is uncertain and fluctuates. The range is from 79,000 to 181,000 units per week. Further, demand has a seasonal pattern.

3. The capacity of the production system is 180,000 units per week.

4. Finsihed goods inventory is 240,000 units. For any finished goods inventory in excess of 240,000 units, there is an extra cost.

5. When production levels are changed from one week to the next, there are hire-fire costs, labeled fluctuation costs.

6. When actual demand exceeds the current week's production plus finished goods inventory a shortage or stock-out results. The shortage is carried over into the next and succeeding weeks until satisfied.

The total cost which a manager attempts to minimize is composed of the following:

1. Production fluctuation cost is a cost incurred by changing the level of production from the previous week. The cost of $0.10 per unit change in production.

2. Regular inventory holding cost is a unit cost as well. For each unit held in finished goods inventory up to and including the 240,000th unit, there is a $0.04 cost. Inventory at the beginning of the first week is zero.

3. Extra inventory holding cost is incurred at the rate of $0.08 per unit for any number of finished goods inventory greater than 240,000 units.

4. Stock-out costs of $0.25 per unfilled unit are incurred when current demand plus previous unsatisfied demand cannot be met with current production and finished goods inventory. The unfilled units are back-ordered and the cost is incurred in succeeding week until backorders are satisfied.

5. Total cost is the sum of the above four costs, i.e.,

   Total Cost = Production fluctuation cost
   + regular inventory holding cost
   + extra inventory holding cost
   + stock-out cost.

The object of the game is to minimize the total cost. This objective can be met by balancing the four costs--that is, by incurring some of each cost to avoid excessive cost occuring in any one area.

The input consists of the manager's social security number, amount of time (in minutes) which the manager took to make the decisions, the level of confidence the manager has in the production decisions (from 1-10), and the number of units to be produced for five weeks. All input is from an interactive terminal, and the input is edited for validity. The input routine is included as Appendix B, and instructions to the user are given in Appendix C.

The program produced four output versions which vary in format and level of summarization but not in content. Examples of the four outputs are given in Appendix D.

To determine the extent to which the decision task was too simple or too complex to affect cognitive differences in decision making, the task was rated by ten production experts to determine task structure as operationally defined by Shaw [31] and used by Fiedler [13]. The task structure dimensions are:

1. Goal clarity: the degree to which the requirements of a task are clearly stated or known to the people performing the task.

2. Goal-path multiplicity: the degree to which the problems encountered in the task can be solved by a variety of procedures.

3. Decision verifiability: the degree to which the correctness of the solutions or decision typically encountered in a job can generally be demonstrated by appeal to authority, by logical procedures, or by logical feedback.

4. Solution multiplicity: the degree to which there is generally more than one "correct" solution involved in the task. [31, p. 10]

Each expert rated each dimension on a five-point Likert-type scale (see Appendix E). Interrater agreement on all four scales was determined by use of Kendall's coefficient of concordance [14, p. 263]. The task was also rated by the subjects. As shown in Table 1, the experts were in close agreement on rating the task, $w = .86$. Also, the experts' mean rating for goal priority was 4.9 with standard deviation of 0.03, indicating that the experts felt the production task goals were clearly stated

to a high degree with little variability. Further, with means of 3.5 for goal path multiplicity with standard deviation of 0.16, 3.7 for decision verifiability with 0.41 standard deviation, and 3.2 for solution multiplicity with 0.38 standard deviation the experts, on the average, indicated from some to a great degree that the problems experienced in completing the production task can be solved by using a variety of procedures, that the correctness of the decisions can be verified in an organizational setting, and that there is more than one correct solution involved in the task, all with relatively little variability. Therefore, the task was considered adequate to represent the production environment.

Table 1 shows that the subjects were also in relatively close agreement in rating the task, w = .70. Also, the subjects, on the average, gave each dimension a rating of between some and a high degree with little variability, which is not inconsistent with the ratings provided by the experts.

Variables in the Study and Research Hypothesis

The experiment was designed to explore the relationship between three independent variables and three dependent variables.

Independent Variables

The three independent variables are:

1. A format variable (F) which was analyzed at two levels, tabular form and graphical form.

TABLE 1

TASK STRUCTURE RATING RESULTS

	MEAN SCORE		STANDARD DEVIATION	
	Experts	Subjects	Experts	Subjects
Goal Clarity	4.9	3.8	0.03	0.02
Goal-Path Multiplicity	3.5	3.2	0.16	0.16
Decision Verifiability	3.7	3.2	0.41	0.21
Solution Multiplicity	3.2	3.1	0.38	0.16

Expert w = .86, n = 10

Subject w = .70, n = 96

2. A level of summarization variable (L) which was analyzed at two levels also, in conjunction with the format variables. The two levels for the level of summarization variable are raw data and statistically summarized data (mean and standard deviation).

3. Psychological type (T) variables, as specified by Mason and Mitroff [23], were used. The psychological type classification is based on Jung's theory of types [10]. The basic premise of the theory is that much apparently random variation in human behavior is actually orderly and consistent. The variation is due to certain basic differences in the way people prefer to use perception and judgement. Perception (G) includes the processes of becoming aware objects, people, occurrences, or ideas. Judgement (E) includes the processes of reaching conclusions about what has been perceived. If managers differ systematically in what they perceive and in the conclusions they reach, then it should be possible to type them by the way they perceive and the way they evaluate the results of their perceptions.

The Myers-Briggs Type Indicator [26, pp. 12-50] was used to determine the psychological type of the subject.

Dependent Variables

1. Cost performance is a relatively unambiguous measure of performance. It is also one of the most commonly used [1, 4, 6, 9, 30]. For this study, the total cost of production was used to measure performance, where total cost of production is the sum of production, fluctuating costs, regular and extra inventory costs, and stock-out costs.

2. Decision time performance was measured by the time elapsed from the time a subject received the reports to the time the subject submitted the decisions for the following week.

3. Decision confidence was measured by a ten-point scale, ranging from one to ten. "1" indicated no confidence, while "10" indicated utmost confidence in the decisions made for that week. Subjects were asked to express their confidence at the time their decisions on production quantity were made.

Research Hypotheses

The proposed research was based on three hypotheses:

H1: The psychological type of the user will have an effect on the decision activity of the user. The performance of the users will vary by psychological type as follows:

Highest -	1.	IT - Intuitive-Thinking type
	2.	ST - Sensation-Thinking type
	3.	IF - Intuitive-Feeling type
Lowest -	4.	SF - Sensation-Feeling type

H2: User performance will be affected by the report format and by the level of summarization of the data, as follows:

Highest -	1.	Graphical, statistically summarized
	2.	Graphical, raw data
	3.	Tabular, statistically summarized
Lowest -	4.	Tabular, raw data

H3: Users of given psychological types will perform better with reports of one combination of format type and level of summarization than with any others, as follows:

Psychological Type	Report
IT	Graphical, SSD
ST	Tabular, Raw Data
IF	Graphical, SSD
SF	Tabular, Raw Data

Experimental Design

A 2^4 factorial design with perception (G) at two levels, evaluation (E) at two levels, and format type (F) and level of summarization (L) at two levels was used for collecting and analyzing the data, as illustrated in Table 2. A total of 96 MBA students were selected by psychological type, using the Myers-Briggs Type Indicator. Each block consisted of four treatment groups (cells). Each

treatment group consisted of six subjects of the appropriate psychological type, randomly assigned (see Appendix G). The random assignment permits the assumption that all other decision-maker characteristics (DM') are randomly distributed among treatment groups. Each group within a psychological type received a treatment consisting of format type and level of summarization of data, as illustrated in Appendix D.

The experiment was conducted over a period of two weeks. Each subject made 13 decisions (13 runs). The first three runs were used to familiarize the subjects with the game, negate the learning effect, and stabilize the gaming process. The subjects completed the experiment in one session at the computer terminals. Each subject was allowed all the time needed to complete the experiment. At a time scheduled by the subject, he reported to the computer laboratory and received the instructions for his role as operations manager (Appendix C). The subject was allowed to study the instructions and to ask questions. When the subject was satisfied that he understood the process, he began the experiment. The subject ran the game in the computer laboratory using a CRT (cathode ray tube) computer terminal. A laboratory assistant was present to help the subject start the simulation, overcome any technical problems with the computer, get the printed report from the line printer, and assure that no confounding variables, such as interruptions, or assistance from other

individuals, were introduced into the experimental process. (See Appendix C for details of running the game.) A $50 prize was awarded for the lowest cost, $25 for the next lowest cost, and $15 for the third lowest cost. Also, T-shirts with the slogan "Jungian Types Have PERSONALITY" were awarded to each participant.

Multivariate analysis of variance (MANOVA) was conducted on the results obtained for the three dependent variables. ANOVA was used for univariate analysis and the Duncan's Multiple Range Test (DMRT) was used to determine significant differences between levels of independent variables.

Following the experiment, a post-experimental questionnaire was administered. The subject was asked (1) what kind of report he would prefer, (2) what kind of additional information, if any, he would have preferred, and (3) his evaluation of the experimental task (see Appendix F).

Research Implications

The basic questions suggested by the three research hypotheses and their implications are discussed below. The first research hypothesis (H1) addresses the question of whether the way in which the user perceives and evaluates what was perceived, as implemented by the Myers-Briggs Type Indicator, generally affects the decisions of the user. The hypothesis was examined by comparing the performance measure of the subjects by psychological type. The anticipated

TABLE 2

Factor Display and Levels

A. Display

Factor:

Information Format	F_1 TABULAR FORMAT								F_2 GRAPHICAL FORMAT							
Data Summarization	L_1 SUMMARIZATION DATA				L_2 RAW DATA				L_1 SUMMARIZATION DATA				L_2 RAW DATA			
Perception Mode	G_1 Sensation		G_2 Intuition		G_1 Sensation		G_2 Intuition		G_1 Sensation		G_2 Intuition		G_1 Sensation		G_2 Intuition	
Evaluation Mode	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL	E_1 THINK	E_2 FEEL

B. Level

Factor	Identification	Level 1	Level 2
F	Information Format	Tabular	Graphical
L	Data Summarization	Raw Data	Mean and Standard Deviation
G	Perception Mode	Sensation	Intuition
E	Evaluation Mode	Thinking	Feeling

performance ranking from highest performance to lowest performance was as follows:

Highest - 1. IT - Intuitive-Thinking type
2. ST - Sensation-Thinking type
3. IF - Intuitive-Feeling type
Lowest - 4. SF - Sensation-Feeling type

The explanation for these expectations is found in the description of the four psychological types [26, pp. 54-55] and the nature of the decision tasks they face.

The intuitive-plus-thinking type (IT) uses intuition for perception but teams it with thinking. This type focuses on possibilities, but approaches them with impersonal analysis. "Often the possibility they choose is a theoretical, technical, or executive one, with the human element subordinated" [25, p. 55]. Given the operational nature of the production game, an individual who perceives in a Gestalt fashion can grasp the key issues of the problem, operate on them in an impersonal analytical manner, and thus should perform well.

The sensation-plus-thinking type (ST) relies primarily on sensing for purposes of perception [26, p. 54]. But he uses thinking for purposes of evaluation [26, p. 54]. The ST type focuses on facts which can be collected and verified by the senses, and makes decisions based on those facts by impersonal analysis [26, p. 54]. Therefore, in the operational environment, individuals of this type should perform well, but not quite as well as those who perceive the "whole" and evaluate it in a logical manner, as the IT types do.

Those in the intuitive-plus-feeling category (IF) should not perform as well as the intuitive-plus-thinking or the sensing-plus-thinking types. Although IF types perceive in a Gestalt manner and see the possibilities, they evaluate on a subjective, good-versus-bad, personal worth basis [26, pp. 54-55]. The cold formality of the operational decision environment is not their forte.

Sensing-plus-feeling types are characterized by their preference for hard facts in perceiving, just as the sensing-plus-thinking types are [26, p. 54]. However, they evaluate in the manner of the intuitive-plus-feeling type, and are interested more in facts about people than about things [26, p. 54]. Although subjects of this type should not perform as well as those of the other types, it should be emphasized that the measurement is relative only to the performance of the other types, and is not absolute.

The implications of these results should be significant in the area of MIS design. One implication is the IT and ST type people make better production managers than IF and SF types. There is some evidence to support this position [26, p. 56]. If this is the case, then the Myers-Briggs instrument could be used by firms as one tool in recruiting production managers. IT and ST types would be ranked above IF and SF types in the selection process.

The second hypothesis, H2, addresses the question of how different combinations of report formats and levels of summarization will affect user performance in general.

This question was explored by comparing the performance measures of the subjects receiving the four different combinations of report formats and levels of summarization:

	Format	Level of Summarization
1.	Tabular (TAB)	Raw Data (RD)
2.	Tabular (TAB)	Statistically Summarized Data (SSD)
3.	Graphical (G)	Raw Data (RD)
4.	Graphical (G)	Statistically Summarized Data (SSD)

Although there have been previous studies on the effects of the level of summarization on performance [1, 6, 22, 30], the results have been mixed. The results of studies on the effects of graphical versus tabular format does indicate that higher performance is reached with the graphic format in one [4] and with the tabular in two others [1, 22].

It was anticipated that the highest performance would come from the graphical-SSD report, followed by the graphical-raw data report, then the tabular-SSD report, and finally the lowest performance from the tabular-raw data report. Amador [1] and Lusk and Kersnick[22] showed higher performance with tabular format, and Benbasat and Schroeder [4] showed higher user performance using a graphical format. Further, in one study, higher performance was demonstrated with statistically summarized data [4], and in another there was no significant difference between statistically summarized and detail data [30]. Since the results of these studies were not significant, and since there is some evidence for the dominance of statistically summarized data, the above ranking is suggested by prior research.

The implications in the area of MIS design are clear. There are times when it would be impractical or even impossible to consider the individual psychological types for whom a report is intended. Therefore, the best report would be the one which gave the highest performance over all psychological types. This, of course, assumes that there is no prior information concerning the proportion of different psychological types in the population of interest. For example, it would be virtually impossible for a firm to match all external and internal reports with the psychological types of the users.

Perhaps the most significant question is raised by the third hypothesis, H3, which proposes that there is one best report combination for each psychological type of user. It was anticipated that the IT type would perform best with the G-SSD report combination, the ST type with the TAB-RD combination, the IF type with the G-SSD combination, and the SF type with the TAB-RD. The reasons for expecting these results are concerned with the characteristics of each psychological type.

Since IT types prefer not to become embroiled with large amounts of facts and since they evaluate in an impersonal manner, it appears reasonable that they would perform best with the graphical format and statistically summarized data report. On the other hand, because of the ST type's preference for detailed hard facts and impersonal and logical evaluation of those facts, it also

seems reasonable to expect ST types to perform best with the tabular format and raw data report.

The expectations for the IF and SF types were also derived from the characteristics of the types, but were arrived at in a different manner. Currently, MIS designs do not present reports in what has been suggested as the most effective form for those psychological types who use the feeling mode for evaluation. Mason and Mitroff argue that "information for feeling types takes the form of 'art,' 'poetry,' 'human drama,' and especially 'strong moral component'" [23, p. 478]. Therefore, it was expected that IF and SF psychological types would rely primarily on their perception process. That is, IF types would perform best with the G-SSD combination and SF types would perform best with TAB-RD combination.

The implication of these findings for MIS design should be highly significant. The implications are as follows:

1. A firm with an existing MIS report structure may hire managers of the psychological type compatible with that structure. A firm with a system that produced G-SSD reports would hire IT types. If the firm's system produced TAB-RD reports, then ST types would be hired. A firm would not hire SF or IF types in a production environment.

2. For a firm with an existing managerial complement, top management could increase the performance of the managers by using the Myers-Briggs instrument to classify the managers by psychological type and by designing the reports to accomodate that type as follows:

Psychological Type	Report Format and Level of Summarization
IT	G-SSD
IF	G-SSD
ST	TAB-RD
SF	TAB-RD

3. Even though the decision environment for this study is limited to the production environment, an implication for the design of reports for top management is also suggested. For reports containing information for decisions similar to production decisions, the report design should follow the scheme for matching report design with psychological type, as given in the preceding paragraph.

CHAPTER 3

EXPERIMENTAL RESULTS

Introduction

Results of the experiment pertaining to the hypotheses are presented in this chapter. For each hypothesis, the results from a MANOVA analysis of the simultaneous effect on the three dependent variables if offered first. Then, the results of a univariate analysis of variance for each independent variable are presented, along with the results from the application of Duncan's Multiple Range Test (DMRT) for detecting significant differences between levels of the appropriate independent variables. A result at $p < .01$ was considered highly significant, while $p < .05$ was considered significant, and $p < .10$ was considered marginally significant.

Results Pertaining to Hypothesis H1

The first hypothesis (H1) predicts that the psychological type of the user will have a simultaneous effect on the performance of the user as measured by the dependent variables, total cost, decision time, and decision confidence. The MANOVA result for analyzing the dependent variables--time, confidence, and cost--by psychological type demonstrates a significant simultaneous effect at ($F = 9.00$, $p < .027$). Thus, the psychological type of

the decision maker does have a significant effect on the three dependent variables jointly, and that portion of H1 is upheld.

The first hypothesis (H1) further predicts that subjects of psychological type IT will have shorter decision times, greater confidence in their decisions, and incur less cost than subjects of the other three types. ST subjects will outperform SF and IF subjects. IF subjects will outperform SF subjects. The expected performance is as follows:

$$IT > ST > IF > SF$$

where the > symbol represents "perform greater than".

To evaluate the individual differences between performance by psychological types, a univariate analysis of variance was run for each dependent variable, time, confidence, and cost, by psychological type, i.e., ST, SF, IT, IF, and the Duncan's Multiple Range Test (DMRT) for detecting significant level differences. As shown in Table 3, IT subjects had the lowest average decision time (4.92 minutes), followed by SF subjects (5.88 minutes), then IF subjects (6.08 minutes), and finally ST subjects with the longest time (6.71 minutes). However, the only significant difference was between IT and ST subjects. Therefore the ordered relationship between time and psychological type predicted by the first hypothesis was not supported.

Referring again to Table 3, ST subjects showed the highest average confidence (7.75), followed in order by SF

and IF subjects at the same average confidence (7.71) and IT subjects (7.46). The differences were not significant and do not support that portion of the first hypothesis.

Results shown in Table 3 indicate that, costwise, SF types performed better overall ($173,187.01) than the other psychological types. Following SF types in cost performance were ST types ($211,915.59), IF types ($242,763.95), and IT types ($369,223.73) in that order. The univariate analysis of variance of cost by psychological type supported the prediction that psychological type would affect cost ($F = 3.278$, $p < .0245$). However, the differences were only significant for SF versus IT types and ST versus IT types. Therefore, that portion of H1 predicting significant differences in performance by levels of psychological types was not supported by the results of the experiment.

Even though a portion of H1 was not supported by the experimental results, further analysis demonstrated a significant difference between cost performance by subjects based on perception (G). Sensing subjects obtained significantly lower costs ($192,551.30) than intuitive subjects ($305,993.84), $F = 5.735$, $p < .018$. As well, univariate analysis of cost performance differences obtained by subjects based on the evaluation variable (E) showed marginally significant lower costs ($207,975,48) for thinking subjects than for feeling subjects ($290,569.66), $F = 2.955$, $p < .088$.

TABLE 3

RESULTS BY PSYCHOLOGICAL TYPE

Psychological Type	Average Decision Time (minutes)	Average Confidence Level	Average Cost
IT	4.92	7.46	$369,223.73
ST	6.71	7.75	$211,915.59
IF	6.08	7.71	$242,763.95
SF	5.88	7.71	$173,187.01

Results Pertaining to Hypothesis H2

The second hypohtesis (H2) concerns the combined effect of format and the level of summarization on a subject's performance. MANOVA comparisons indicate that the type of the report used has a highly significant effect on performance as measured simultaneously by time, confidence, and cost ($F = 3.00$, $p < .002$). Further, as predicted by the hypothesis, subjects with the different report types should perform in the following order:

Highest:
1. Graphical - Statistically Summarized Data (G-SSD)
2. Graphical - Raw Data (G-RD)
3. Tabular - Statistically Summarized Data (TAB-SSD)
4. Tabular - Raw Data (TAB-RD)

Table 4 provides the results for average decision time, average confidence, and average cost by report type.

According to the results shown in Table 4, subjects with G-SSD report averaged the shortest decision time (5.33 minutes) as predicted. However, the second shortest decision time was obtained by subjects with the TAB-SSD report (5.88 minutes) instead of those with G-RD report (6.08 minutes) as predicted. Thus, the resulting order of performance does not support the hypothesis for decision time performance by report type. As well, the differences observed for time by report type were not significant.

The predicted order of performance as measured by confidence level was not substantiated by the results, as shown in Table 4. Subjects receiving G-SSD reports finished next to last in the rankings of confidence (7.33), while subjects with G-RD reports or TAB-SSD reports exhibited the highest confidence (8.08). However, even though the predicted order of finish was not borne out, the differences in confidence between subjects using G-RD and TAB-SSD and those using G-SSD and TAB-RD are marginally significant.

A one-way analysis of variance of cost by report type revealed a highly significant main effect on cost by report type ($F = 4.946$, $p < .003$). However, subjects with G-SSD reports were predicted to obtain the best cost performance. Instead, as shown in Table 4, they obtained the highest cost. G-RD reports provided the lowest cost, followed by TAB-SSD, and finally by G-SSD. Therefore, the order of performance by cost predicted by the hypothesis was not borne out. But, the DMRT analysis demonstrated that cost performance for subjects with G-RD and TAB-RD reports was significantly better than those with TAB-SSD or G-SSD. These results imply that, based on cost, subjects with RD reports outperformed those with SSD reports. This implication was substantiated by the results of a one-way analysis of variance of cost by the level of summarization variable (L). Subjects using raw data (RD) reports obtained a cost of $164,778.85 versus $333,766.29 for subjects using statistically summarized data reports (SSD), ($F = 13.75$,

TABLE 4

RESULTS BY REPORT TYPE

Report Type	Average Decision Time (minutes)	Average Confidence Level	Average Cost
G-SSD	5.33	7.33	$301,649.02
G-RD	6.08	8.08	$158,054.10
TAB-SSD	5.88	8.08	$298,835.30
TAB-RD	6.29	7.13	$171,503.60

$p < .0004$). A highly significant simultaneous effect on time, confidence, and cost by level of summarization (L) was indicated by MANOVA results ($F = 6.37$, $p < .0006$). The same MANOVA run showed no significant effect by format (F).

Results Pertaining to Hypothesis H3

The third hypothesis (H3) proposes that there is a best (in terms of performance) report type for each psychological type as follows:

Psychological Type	"Best" Report Type
IT	G, SSD
ST	TAB, RD
IF	G, SSD
SF	TAB, RD

Table 5 gives the results for IT types by report type, while Table 6 provides the results for ST types. Results for IF types are shown in Table 7, and those for SF types are given in Table 8.

A MANOVA was run for each psychological type by report type. The analysis showed a significant simultaneous effect on time, confidence, and cost by report type when the psychological type variable was controlled for all psychological types, with the exception of IT's. For ST types, the level of significance was $p < .043$, $F = 2.171$, for IF types, $p < .001$, $F = 3.785$, and for SF types, $p < .00001$, $F = 8.073$.

As shown in Table 5, IT types made decisions in the least amount of time using G-RD reports (4.33 minutes). However, they exhibited the greatest confidence with G-SSD reports (8.50) and the least cost with TAB-RD reports ($221,375,50). Examination with DMRT showed no significant differences for IT's by report in performance, measured in time. IT's did show significantly less confidence in the TAB-RD report type than in the other three report types ($p < .050$), 5.83 for TAB-RD versus 7.67 for TAB-SSD, 7.83 for G-RD, and 8.05 for G-SSD. However, there was no significant difference between IT's confidence in TAB-SSD, G-RD, and G-SSD reports. Further, the cost differences by report type for IT's were not significantly different. Although the cost results were not significantly different, it is interesting to note that IT types had the least confidence (5.83, significant at $p < .05$) in the report type with which they obtained the least cost (TAB-RD) and the greatest confidence (8.50) in the report type with which they obtained the highest cost (G-SSD).

As shown in Table 6, ST types took the least amount of time for decisions using G-SSD reports (4.50 minutes), had the greatest confidence in G-RD reports (8.00), and obtained the least cost with G-RD reports ($93,302.56). Univariate analysis by one-way ANOVA showed significant main effects for time ($F = 4.495$, $p < .0144$), but not for confidence or cost.

TABLE 5

RESULTS FOR IT TYPES BY REPORT TYPE

Report Type	Decision Time (minutes)	Level of Confidence	Total Cost
TAB-RD	4.83	5.83	$221,375.56
TAB-SSD	5.17	7.67	$386,861.70
G-RD	4.33	7.83	$334,613.47
G-SSD	5.33	8.50	$534,044.22

Examination of time performance by ST's with DMRT showed that ST's used marginally significant more time to make decisions with TAB-SSD reports (9.67 minutes) than with TAB-RD (6.83 minutes), G-RD (6.33 minutes), and G-SSD (6.83 minutes). Also, ST's used significantly less decision time with G-SSD reports than with TAB-RD and TAB-SSD reports. However, the difference in time involving G-SSD reports and G-RD reports was not significant.

DMRT analysis of cost performance by ST types indicates that ST's obtained marginally significant lower costs ($93,302.56) with G-RD types than with TAB-SSD ($238,113.26) and G-SSD ($298,216.07) reports, but the difference between G-RD and TAB-RD was not significant. The differences in level of confidence were not significant.

As shown in Table 7, IF types exhibited the shortest decision time with TAB-SSD reports (4.00 minutes), the greatest confidence with TAB-SSD and G-RD reports (8.50) and the least cost with G-RD reports ($79,239.98). Univariate analysis by one-way ANOVA showed highly significant effects for cost ($F = 6.457$, $p < .003$). The differences for time and confidence were not significant.

Post-hoc DMRT analysis indicates that IF's used a significantly larger amount of time to make a decision using TAB-RD reports (8.33 minutes) than TAB-SSD reports (4.00 minutes). The other time differences were not significant. Nor were the differences in confidence among the report types.

TABLE 6

RESULTS FOR ST TYPES BY REPORT TYPE

Report Type	Decision Time (minutes)	Level of Confidence	Total Cost
TAB-RD	6.83	7.67	$218,030.46
TAB-SSD	9.17	7.83	$238,113.26
G-RD	6.33	8.00	$ 93,302.56
G-SSD	4.50	7.50	$298,216.07

IF's using TAB-SSD reports had significantly higher costs ($468,392.35) than IF's using any of the other report types. The cost differences between IF's using TAB-RD, G-RD, and G-SSD types were not significant.

In Table 8, one can see that SF types obtained the shortest decision time using TAB-RD and TAB-SSD reports (5.17 minutes). While SF's using TAB-SSD had the greatest confidence (8.33), and those with the least cost had TAB-RD reports ($83,650.62). Univariate analysis with one-way ANOVA showed highly significant effects with cost ($F = 16.047$, $p < .00001$) and time ($F = 8.672$, $p < .007$). However, there was no significant effect on confidence.

Analysis by DMRT showed that SF's with TAB-RD and TAB-SSD reports had significantly shorter decision times (5.17 minutes) than SF's with G-RD (6.83 minutes) and G-SSD (6.33 minutes). There was no significant difference between decision times for SF's with G-RD and G-SSD reports.

SF's using TAB-RD reports ($83,650.62), TAB-SSD reports ($83,973.88), and G-RD reports ($125,060.35) had significantly lower costs than SF's using G-SSD reports ($400,063.21). There was no significant difference in cost between SF's using TAB-RD, TAB-SSD, and G-RD reports. DMRT analysis, as well, detected no significant differences between the confidence of SF's using the different report types.

The results concerning the third hypothesis (H3) indicate that report type had a significant simultaneous

TABLE 7

RESULTS FOR IF TYPES BY REPORT TYPE

Report Type	Decision Time (minutes)	Level of Confidence	Total Cost
TAB-RD	8.33	7.33	$162,957.80
TAB-SSD	4.00	8.50	$486,392.35
G-RD	6.83	8.50	$ 79,239.98
G-SSD	5.17	6.50	$242,465.69

TABLE 8

RESULTS FOR SF TYPES BY REPORT TYPE

Report Type	Decision Time (minutes)	Level of Confidence	Total Cost
TAB-RD	5.17	7.67	$ 83,650.62
TAB-SSD	5.17	8.33	$ 83,973.88
G-RD	6.83	8.00	$125,060.35
G-SSD	6.33	6.83	$400,063.21

effect on all three dependent variables (time, confidence, and cost) for all psychological types with the exception of the IT type. However, no report type was significantly better for IT types than any other. Also, there was no one best report type for ST, SF, or IF types. Therefore, the third hypothesis (H3) was not supported by experimental results.

CHAPTER 4

DISCUSSION OF RESULTS

Introduction

The experimental results are discussed in the following pages with respect to the research implications stated in Chapter 2. In addition, the experimental results presented in Chapter 3 are compared to the results of previous studies. Finally, the results of the post-experimental questionnaire are presented and their relationship with the experimental results are discussed.

Implications of Hypothesis H1

The implications following from the first hypothesis are concerned with the selection of employees as production managers if these experimental results could be demonstrated in an actual production environment. Assuming that minimization of production costs is desirable for an organization, then the organization should use, as one of its selection criteria, the decision-making type of the prospective employee.

Since SF and ST types performed significantly better than IT types in cost performance, given a choice among SF, ST, and IT types with all other things being equal, either the ST or SF types should be selected. Further, if

the organization has information on only the perceptual type of the prospective employees available for use in the selection process, then the sensing type should be selected, all other things being equal. This inference is indicated by the significantly better cost performance of sensing subjects versus intuitive subjects reported in Chapter 3. If, on the other hand, the only information concerning the decision-making type of the individual is their evaluation type, then the thinking type should be selected, all other things being equal. This inference is made from the significantly better cost performance of thinking subjects versus that of feeling subjects reported in Chapter 3.

Implications of Hypothesis H2

The implications of hypothesis H2 as outlined in Chapter 2 addresses the situation in which an organization lacks knowledge of the distribution of decision-making types of individuals receiving reports within the organization. Another situation an organization faces is the design of reports for external users. In both of the foregoing situations, or any others where it would be impractical or impossible to consider the psychological type of each individual for whom a report is intended, the best report would be the one which provided the best performance over all psychological types. Given that the experimental results were replicated in an actual production environment.

Results reported in Chapter 3 pertaining to hypothesis H2 show that, costwise, subjects using G-RD and TAB-RD reports significantly outperformed subjects using G-SSD and TAB-SSD reports, with no significant difference observed between subjects with G-RD and TAB-RD reports or between subjects with G-SSD and TAB-SSD reports. Further investigation demonstrated that subjects using RD reports performed significantly better costwise than subjects using SSD reports, while differences in format were not significant.

Although the results are not generalizable across all decision environments, they do suggest that for reports within a production type of environment, the best report for cost performance where the decision type of the user is unknown is one with raw data (RD) level of summarization either tabular (TAB) or graphical (G) format. This suggests that MIS designers, for the most part, have been doing the right thing in producing primarily TAB-RD or G-RD reports.

Implications of Hypothesis H3

The first implication following from the results for hypothesis H3 as outlined in Chapter 2 is concerned with the organization which has an existing MIS report structure. Assuming these experimental results could be found in an actual production situation, it is logical that the firm would be interested in hiring managers whose psychological

type is compatible with that structure. Following the above logic, a firm with an existing report structure dominated by TAB-RD reports should hire SF or IF types as production managers. This inference follows from the experimental results which showed SF and IF types performing significantly better costwise with TAB-RD reports.

For a firm whose existing MIS structure is dominated by G-RD reports, the above logic dictates the hiring of ST, IF, or SF types as production managers. Again, the inference which follows from experimental results shows that SF types performed better with G-RD reports than with TAB-RD and G-SSD reports. Further, SF and IF types showed significantly better cost performance with G-RD reports as well as with TAB-RD reports, as mentioned in the previous paragraph, and therefore would qualify for priority consideration as production managers in G-RD report-dominated MIS systems, along with ST types.

For a firm with G-SSD report-dominated MIS systems, there appears to be only one decision-making type demonstrating compatibility with this report structure. Subjects of the IF type were the only ones whose cost performance with G-SSD reports was not worse than their cost performance with the other three reports. Further, the differences in cost performance was significant for ST's between G-RD and G-SSD reports, and for SF's between G-SSD and all other reports types.

A firm whose MIS is dominated by a TAB-SSD report structure should consider SF types for production managers, all other things being equal. Experimental results indicate that SF types demonstrated significantly lower costs with TAB-SSD, G-RD, and TAB-RD reports versus G-SSD reports, and thus are compatible with the TAB-SSD reports structure.

Even though IT types showed no significant difference in cost performance with different report types, their poor cost performance relative to the other decision-making types indicates their incompatibility with the production environment itself. Perhaps, the implication is that IT types should not be considered for production employment, all other things being equal.

Another implication from hypothesis H3 is that, for a firm with an existing managerial complement, performance for the firm's production managers may be increased using the Meyers-Briggs instrument to classify production managers by psychological type and designing the production reports to accomodate the managers' psychological type. Experimental results indicate that managers may be able to use more than one report type, as explained in the following paragraphs.

Based on cost performance alone, production managers of the ST type should receive G-RD reports, even though they use less time with both G-SSD and G-RD reports. Results of the experiment indicate ST's do have the greatest confidence in G-RD reports; however, the difference was not significant.

SF production managers can use either TAB-RD, TAB-SSD, or G-RD reports, according to experimental cost performance results. Since differences in the costs between SF subjects using those reports can be due to random effects, either of the three report types would be appropriate for SF's. However, SF production managers should use less decision time with TAB-RD and TAB-SSD reports than G-RD reports. Thus, the findings suggest that SF production managers would benefit from TAB-RD or TAB-SSD reports.

Experimental cost performance by IF subjects suggests that IF production managers should receive either TAB-RD, G-RD, or G-SSD reports, since there was no significant difference between the performance of subjects using those reports, and the difference between cost performance of subjects with those reports and subjects with TAB-SSD reports were significant, as reported in Chapter 3. However, since IF subjects with G-RD reports used significantly more decision time than those using TAB-SSD reports, G-RD reports show conflicting performance results and are eliminated from suggested reports for IF production managers. Experimental results show no significant differences in confidence for IF subjects. Thus the findings imply that IF production managers would benefit from TAB-RD and G-SSD reports.

As mentioned previously, the relatively poor performance of IT types in this experiment suggest that the production environment is not the forte of IT types.

Further, based on cost performance, no report type is better than any other for IT types, since the differences between report types were not significant for IT's, as reported in Chapter 3. Decision time was not a differentiating factor either. However, experimental results did show significantly less confidence in TAB-RD report type than the other report types. This finding does suggest, rather weakly, that the TAB-RD report could be eliminated from those presented to IT production managers, based on confidence.

The final implication arising from hypothesis H3, as outlined in Chapter 2, is concerned with the design of reports for top management. Even though the decision environment for this study was limited to production, and the findings are not generalizable beyond that environment, it is suggested that, for top management reports containing information similar to production decisions, the report design should follow the scheme for report designs consistent with the findings of this study. Thus, top managers of a particular psychological type would receive the report type specified in the previous paragraphs.

Top managers of the ST type would receive information for production-type decisions in G-RD reports, SF top managers either TAB-RD or TAB-SSD reports, IF top managers either TAB-RD or G-SSD reports, while IT top managers may use any of the report types with relatively the same results.

Comparison with Other Studies

The results of the present study concerning the effects of the DM and CIS variables confirm the results of some previous studies and conflict with others. The following paragraphs describe the confirmation and differences, and suggest some reasons for the differences.

Previous studies of the effects of cognitive style (DM) on performance within the context of an MIS by Benbasat and Schroeder [4], Kozar [20], and Lusk and Kersnick [22] have shown no significant effects due to the cognitive type of the decision maker. The primary difference between the structure of the studies pertaining to cognitive type is the instrument used to measure the attribute as detailed in Chapter 1. Benbasat and Schroeder used the WCFAFT [4], Kozar used quantitative scores on the ATGSB [20], Lusk and Kersnick used the EFT while the MBTI was used in the present study.

As reported in Chapter 3, significant effects, both univariate and multivariate, were found due to cognitive type of the decision maker. The foregoing suggests that the MBTI is the instrument that will provide the most rewarding results in future MIS research on cognitive style.

As presented in Chapter 1, results from previous studies have been mixed on the effects of format on user's performance. Amador's results [1] and Lusk and Kersnick [22] showed higher performance with tabular format, while Benbasat and Schroeder's results showed higher performance

using graphical format [4]. The present study, as stated in Chapter 4, found no significant differences in performance due to main effects of format using either univariate or multivariate models of analysis of variance for investigation. A possible reason for the lack of a significant main effect due to format is the similarity of the tabular and graphical formats (Appendix D). The use of bar graphs to represent graphical form might not offer sufficient differentiation of graphical versus tabular format.

The effect of the level of summarization variable on performance found in previous studies is mixed, as reported in Chapter 1. Amador [1] found significant results using a multivariate model, while Chervany and Dickson [6], Senn and Dickson [30], and Lusk and Kersnick [22], using univariate models for investigation, did not. The present study, as reported in Chapter 4, found that subjects with raw data (RD) reports significantly outperformed subjects with statistically summarized data (SSD) reports, when analyzed with either univariate or multivariate models.

Discussion of Post-Experimental Questionnaire Results

Results of the post-experimental questionnaire are shown in Table 9. First, a distribution of report type preferences is shown by psychological type. Next is shown the distribution by psychological type of the percent of that type which preferred a report type other than the one received in the study. The last distribution shows the percent of subjects by psychological type that wanted additional information.

As indicated in the first distribution, 87 percent of ST's preferred TAB-RD reports, while 13 percent preferred TAB-SSD reports, with none preferring the other two report types. Further, examination of Table 9 shows that 63 percent of the ST's preferred a report other than the one they received. This preference for the TAB-RD report by ST's conflicts with the experimental results, which show the best performance costwise by ST's is with G-RD reports versus TAB-SSD and G-SSD reports, and no significant difference between performance by ST's with TAB-RD reports and other report types. The foregoing suggests that the report types preferred by ST production managers are not the ones they use to the best advantage.

Table 9 shows that only 25 percent of ST's wanted additional information in their reports, while 75 percent were satisfied with the information the recieved. These figures indicate that ST subjects were satisfied with the content of the reports supplied for the experiment.

Table 9 shows that 87 percent of SF's preferred TAB-RD reports, while 13 percent preferred TAB-SSD reports--the same distribution demonstrated by ST's. Further, 50 percent of the SF's preferred a different report than the one they received. The preferences demonstrated by SF's is not in conflict with experimental results, since SF's cost performance with TAB-RD reports was the best, although not

significantly different from performance with TAB-SSD and G-RD reports.

SF subjects viewed additional information the same as ST types did. Only 25 percent of SF's wanted additional information. Again, this suggests that SF's, for the most part, were satisfied with the content of the reports they received during the experiment.

Table 9 shows that 61 percent of IT's preferred TAB-RD reports, 6 percent preferred G-RD reports, 17 percent preferred G-SSD reports, 6 percent preferred TAB-SSD reports, and 10 percent preferred a report type other than the ones offered in the experiment. Further, 83 percent of IT's reported a preference for a report type other than the ones they received. The reported preferrences by IT's are not inconsistent with the experimental results. IT subjects performed best costwise with TAB-RD report type. However, there was no significant difference between the performance of IT's using the TAB-RD and IT's using other report types.

Only 16 percent of the IT subjects reported a desire for additional information. Thus IT's were, for the most part, satisfied with the content of the reports received in the experiment.

Report preference by IF's from Table 9 indicate that 75 percent of the IF's preferred TAB-RD reports, while 13 percent preferred G-RD reports and 12 percent preferred G-SSD reports. Also shown in Table 9 is the fact that

63 percent of IF's were unhappy with the report types they received and would have preferred another type of report. The reported preferences are consistent with the experimental results for IF performance. Costwise, IF subjects performed significantly worse with TAB-SSD reports than IF's using any other report type. As reported in Chapter 4, IF's performed best with G-RD reports, followed by TAB-RD reports and G-SSD reports, in that order. However, the differences between these three reports were not significant.

As shown in Table 9, IF subjects were the only psychological category to want additional information. They indicated that content of the reports received was not sufficient by 63 to 27 percent.

Overall, subject responses were not inconsistent with their experimental performance. The overwhelming preference for TAB-RD reports could be a matter of conditioning due to the prevalence of TAB-RD reports incorporated in most information systems report structures. Also, the dissatisfaction of the majority of subjects with the report type they received implies a lack of familiarity with the more unorthodox report types, not necessarily their inability to perform with those report types. Finally, the dissatisfaction reported by IF types with the content of the reports received in the study could well be due to an attribute of that psychological type suggested earlier in Chapter 1, that IF's perform best and are more attuned to narratives and visual imagery.

TABLE 9

RESULTS OF POST-EXPERIMENTAL QUESTIONNAIRE

Report Preferences (Percent)

	ST	SF	IT	IF
TAB-RD	87	87	61	75
G-RD	0	0	6	13
G-SSD	0	0	17	12
TAB-SSD	13	13	6	0
OTHER	0	0	10	0

Percent That Preferred Report Other Than One Received

ST	SF	IT	IF
63	50	83	63

Percent That Wanted Additional Data

ST	SF	IT	IF
25	25	16	63

CHAPTER 5

SUMMARY AND POSSIBLE EXTENSIONS

This research was motivated by the relative scarcity of empirical research dealing with management information systems and the lack of significant findings and conflicting evidence from previous studies pertaining to the effects of cognitive type of the user and report type on user performance. An experimental model for user performance involving three dependent variables (user confidence, decision time, and production cost) and three independent variables (characteristics of the decision maker, characteristics of the decision environment, and characteristics of the information system) was used in the study. The model was used to examine the effects on performance by four different report types and four different psychological (decision making) types of production managers. Ninety-six MBA students participated as surrogate managers.

Three general hypotheses were tested relative to the effects of the report type (format and level of summarization) treatments on the performance of subjects of each psychological type. Portions of each hypothesis were supported by the experimental results. However, as with all experimental research, questions concerning the results

of this study are possible, and in that area, the present study is not exempt.

As pointed out by Amador [1, p. 63], using students as surrogate managers is a limitation in any study. A necessary extension of the present study would be an experimental study using real-life production managers. A further extension would be controlled studies with real-life production managers in a real-world site. This would provide external validity for the study and important additions to knowledge in the MIS design field.

Further investigation is needed into the relatively poor performance of IT types in the production environment. Perhaps this particular psychological type is more attuned to other decision environments in an organization. A modification of the experiment to consider other decision environments is a logical extension.

Another area requiring study is the apparent dissatisfaction of IF types with the traditional forms of reports, as indicated by their responses on the post-experimental questionnaire. As suggested by Mason and Mitroff [23], IF's may perform better with narrative reports and pictures.

In addition to increasing the types of reports, a greater differentiation is required between tabular and graphic report formats. The lack of a significant effect due to format is very possibly due to the close similarity of the representations of tabular and graphic in the present

study. Possibly the use of continuous plots to represent graphical format would be the key.

Another area of consideration is the extension of the decision environment to consider strategic level decisions. Items of interest would be what kinds of report types benefit performance at that level, and what psychological types provide the best performance at that level.

Finally, the results of this study imply that, as suggested by Amador [1] and Barkin and Dickson [3], the use of multivariate models are of significant value in this type of study. Where effects on dependent variables considered individually are sometimes not detected, those effects on all the dependent variables considered jointly can be significant. In particular, each MANOVA test in the present study detected significant results, while many of the univariate tests did not. The use of multivariate tests permits the use of information lost in the univariate tests.

REFERENCES

1. Amador, Jose A., "Information Formats and Decisions Performance: An Experimental Investigation", Ph.D. Dissertation, University of Florida, 1977.

2. Aron, Joel D., "Information Systems in Perspective", Computing Surveys, Vol. 1 (December, 1969), pp. 213-236.

3. Barkin, S.R., and Dickson, G.W., "An Investigation of Information System Utilization", Information and Management, Vol. 1 (November, 1977), pp. 35-45.

4. Benbasat, I., and Schroeder, R.G., "An Experimental Investigation of Some MIS Design Variables", The Management Information Systems Quarterly, Vol. 1 (March, 1977), pp. 37-49.

5. Carlyn, Marcia, "An Assessment of the Myers-Briggs Type Indicator", Journal of Personality Assessment, Vol. 45, No. 5 (1977), pp. 461-473.

6. Chervany, N.L., and Dickson, G.W., "An Experimental Evaluation of Information Overload in a Production Environment", Management Science, Vol. 20 (June, 1974), pp. 1335-1344.

7. Churchill, Gilbert A., Jr., Marketing Research, Methodological Foundations, 2nd ed., The Dryden Press, Hinsdale, Illinois, 1978.

8. Davis, Gordon, B., Management Information Systems: Conceptual Foundations, Structure and Development, McGraw-Hill, New York, 1974.

9. Dickson, G.W., Chervany, N.L., and Kozar, K.A., "An Experimental Gaming Framework for Investigating the Influence of Management Information Systems on Decision Effectiveness", Management Information Systems Working Paper Series, MISRC-WP-72-12, University of Minnesota, Minneapolis, Minnesota, April, 1972.

10. _____, Senn, J.A., and Chervany, N.L., "Research in Management Information Systems: The Minnesota Experiments", Management Science, Vol. 23 (May, 1977), pp. 913-933.

11. Driver, M.J., and Mock, T.J., "Human Information Processing, Decision Style Theory, and Accounting Information Systems", The Accounting Review, Vol. 1 (July, 1975), pp. 490-508.

12. Fellingham, J.C., Mock, T.J., and Vasarhelyi, M.A., "Simulation of Information Choice", Decision Sciences, Vol. 7 (April, 1976), pp. 219-234.

13. Fiedler, Fred E., "A Contingency Model of Leadership Effectiveness", Advances in Experimental Social Psychology, Berkowitz, Leonard, ed., Academic Press, New York, 1964, Vol. 1, pp. 149-190.

14. Gibbons, Jean D., Nonparametric Methods for Quantitative Analysis, Holt, Rinehart, and Winston, New York, 1976.

15. Hanold, Terrance, "An Executive View of MIS", Datamation, Vol. 11 (November, 1972), pp. 65-71.

16. Harris, Roy D., and Maggard, Michael J., Computer Models in Operations Management, Harper and Row Publishers, Inc., New York, 1972, pp. 197-220.

17. Hellriegel, Don, and Slocum, J.W., Jr., "Managerial Problem Solving Styles", Business Horizons, Vol. 18, No. 6 (December, 1975), pp. 27-39.

18. Jung, C.G., Analytical Psychology, Its Theory and Practice, Vintage Books, New York, 1968.

19. Kilmann, Ralph H., and Taylor, Vern, "A Contingency Approach to Laboratory Learning: Psychological Types Versus Experimental Norms", Human Relations, Vol. 27, No. 9 (1974), pp. 891-909.

20. Kozar, K.A., "Decision Making in a Simulated Environment: A Comparative Analysis of Computer Display Media", Ph.D. Dissertation, University of Minnesota, 1973.

21. Lucas, H.C., "Performance and the Use of an Information System", Management Science, Vol. 21 (April, 1975), pp. 908-919.

22. Lusk, Edward J., and Kersnick, Michael, "The Effect of Cognitive Style and Report Format on Task Performance: The MIS Design Consequences", Management Science, Vol. 29 (August, 1979), pp. 787-798.

23. Mason, R.D., and Mitroff, I.I., "A Program for Research on Management Information Systems", Management Science, Vol. 19 (January, 1979), pp. 475-547.

24. McKenney, James L., and Keen, P.G., "How Managers' Minds Work", Harvard Business Review, Vol. 44, No. 3 (May-June, 1974), pp. 79-90.

25. Mitroff, II., and Kilmann, R.H., "On the Importance of Qualitative Analysis in Management Science: The Influence of Personality Variables on Organizational Decision-Making", Working Paper, Graduate School of Business, University of Pittsburgh, Pittsburgh, Pennsylvania, 1974.

26. Myers, I.B., Myers-Briggs Type Indicator, Educational Testing Service, Princeton, New Jersey, 1962.

27. Pokempner, Stanley J., "Management Information Systems--A Pragmatic Survey", The Conference Board Record Vol. 1 (May, 1973), pp. 49-54.

28. Radford, K.J., Information Systems for Strategic Decisions, Prentice-Hall, Inc., New York, 1978.

29. Schroeder, R.G., and Benbasat, I., "An Experimental Evaluation of the Relationship and Uncertainty in the Environment to Information Used by Decision Makers", Decision Sciences, Vol. 6 (July, 1975), pp. 556-567.

30. Senn, J.A., and Dickson, G.W., "Information System Structure and Purchasing Decision Effectiveness", Journal of Purchasing and Materials Management, Vol. 10 (August, 1974), pp. 776-783.

31. Shaw, Marvin E., Scaling Group Tasks: A Method for Dimensional Analysis, Technical Report No. 1, University of Florida, July, 1963.

32. Simon, Herbert A., The New Science of Management Decision, Prentice-Hall, Inc., New York, 1977.

33. Small, John T., and Lee, William B., "In Search of MIS", MSU Business Topics, Vol. 1 (Autumn, 1975), pp. 47-55.

34. Smith, August., W., and Urban, Thomas F., "Myers-Briggs Personality Orientations and Information Processing Styles: Implications for Management Education and Development", National Academy of Management, MED Session, San Francisco, August 10, 1978.

35. Van Gigch, John P., Applied General Systems Theory, 2nd ed., Harper and Row, New York, 1978.

36. Witkin, H., Dyk, R., Faterson, H., Goodenough, D., and Karp, S., Psychological Differentiation, Wiley and Sons, New York, 1962.

37. _____, Goodenough, D., and Karp, S., "Stability of Cognitive Style from Childhood to Young Adulthood", Journal of Personality and Social Psychology, Part I, Vol. 7 (November, 1967), pp. 73-84.

38. Zmud, Robert W., "On the Validity of the Analytic-Heuristic Instrument Utilized in The Minnesota Experiments", Management Science, Vol. 24 (June, 1978), pp. 1088-1098.

APPENDIX A

SIMPRO LISTING

```
      PROGRAM SIMPRO(OUT,MASIN1,MASIN2=/225,WORKIN,WORKOT,DECS,
     +       MSOUT1,MSOUT2=/225,OUTPUT,TAPE6=OUTPUT,
     +       TAPE4=OUT,TAPE7=MASIN1,TAPE8=MASOUT1,TAPE9=WORKIN,
     +       TAPE1Ø=WORKOT,TAPE11=DECS,TAPE12=MASIN2,TAPE14=MSOUT2)
      COMMON PRPL(5Ø),DMDNR(5Ø),DMD(5Ø),CPCG,CEXI,CSKO,
     +       CRI,ISN,INM1,INM2,ITP,IBLK,RSTA(1Ø,3),NBR,BI,TPFC,TEIHC,
     +       TRIHC,TSKOC,TCOST,OSPRO,BO,ENIN(5Ø),PRFL(5Ø),
     +       RIC(5Ø),EIC(5Ø),SOC(5Ø),TCW(5Ø),EI,PDCOST
      CPCG= Ø.1Ø
      CRI= Ø.Ø2
      CEXI = Ø.Ø6
      CSKO = Ø.25
      REWIND  7
      REWIND  9
      REWIND  11
      XM1=SECOND(CP)
      XM1=1ØØ*XM1
      NN=INT(XM1)
      JJ=MOD(NN,2)
      IF(JJ .EQ. Ø) GO TO 5
      M1=NN
      GO TO 6
    5 M1=NN+1
    6 M2=Ø
   2Ø  READ(9,21ØØ) NIAW,IBLKW,NBR,BI,TPFC,TRIHC,TEIHC,TSKOC,
     +       TCOST,BO,OSPRO
      IF (NBR.GT. 5Ø) CALL ATEND(TCOST)
   3Ø  READ(7,2ØØØ) ISN,INM1,INM2,ITP,IBLK
      READ(12,2Ø1Ø) ((RSTA(I,J),J=1,3),I=1,1Ø)
      N = NBR + 4
      READ(11,22ØØ) NID,DT,DC,(PRPL(I),I=NBR,N)
      CALL FCAST(NBR)
      CALL ADMAND(NBR,M1,M2,RN)
      CALL PROD
      J = NBR + 5
      CALL FCAST(J)
      CALL POUT
      NBR = NBR + 5
      CALL UPDT(NIAW,IBLKW,DT,DC)
       IF (NBR .GT. 5Ø) CALL ATEND(TCOST)
2ØØØ FORMAT(I9,2A1Ø,A4,I2)
2Ø1Ø FORMAT(8(F12.2,F4.Ø,F3.Ø)
21ØØ  FORMAT(I9,2I2,F8.Ø,5F1Ø.2,2F8.Ø)
22ØØ FORMAT(I9,F4.Ø,5F8.Ø)
      END
      SUBROUTINE FCAST(NWK)
      COMMON PRPL(5Ø),DMDNR(5Ø)
      N=NWK=4
   1Ø DO 2Ø I = NWK,N
   2Ø DMDNR(I)=1ØØØØØ+(3ØØØØ*SIN((I/12.Ø)*6.28318))+1ØØØ*I
      RETURN
      END
      SUBROUTINE ADMAND(NBR,M1,M2,RN)
      COMMON PRPL(5Ø),DMDNR(5Ø),DMD(5Ø)
```

```
      M = NBR+$
      DO 4Ø I = NBR, M
      TM = DMDNR(I)
      TSD = .Ø5*TM
      Z = Ø
      DO 3Ø N = 1,12
      CALL RAN(M1,M2,RN)
      Y=RN
   3Ø Z = Z + Y
      RV= (Z-6)/4
   4Ø DMD(I) = RV * TSD + TM
      RETURN
      END
      SUBROUTINE PROD
      COMMON PRPL(5Ø),DMDNR(5Ø),DMD(5Ø),CPCG,CEXI,CSKO
     +       CRI,ISN,INM1,INM2,ITP,IBLK,RSTA(1Ø,3)NBR,BI,TPFC,TEIHC,
     +       TRIHC,TSKOC,TCOST,OSPRO,BO,ENIN(5Ø),PRFL(5Ø),
     +       RIC(5Ø),EIC(5Ø),SOC(5Ø),TCW(5Ø),EI,PDCOST
      M=NBR+4
       PDCOST=Ø.
       IF (NBR .EQ. 1) OSPRO = PRPL(1)
      DO 32 IT = NBR, M
      PROSC = PRPL(IT)
      EI = BI+PROSC-DMD(IT)-BO
      IF (EI) 26,27,27
   26 BO = -EI
      EI = Ø
      GO TO 28
   27 BO = Ø
   28 CONTINUE
      PFC = ABS(OSPRO-PROSC)*CPCG
      IF (EI-24ØØØØ) 29,29,30
   29 RIHC = EI*CRI
      EIHC = Ø
      GO TO 31
   3Ø EIHC = (EI-24ØØØØ)*CEXI
      RIHC = 24ØØØØ*CRI
   31 CONTINUE
      SKOC = BO*CSKO
      TOTC = PFC+RIHC+EIHC+SKOC
      ENIN(IT) = EI
      PRFL(IT) = PFC
      RIC(IT)  = RIHC
      EIC(IT)  = EIHC
      SOC(IT)  = SKOC
      TCS(IT)  = TOTC
       PDCOST=PDCOST + TOTC
      TPFC = TPFC + PFC
      TRIHC = TRIHC + RIHC
      TEIHC = TEIHC + EIHC
      TSKOC = TSKOC + SKOC
      TCOST = TCOST + TOTC
      BI = EI
      OSPRO = PROSC
```

```
32 CONTINUE
   RETURN
   END
   SUBROUTINE POUT
   COMMON PRPL(5Ø),DMDNR(5Ø),DMD(5Ø),CPCG,CEXI,CSKO,
  +        CRI,ISN,INM1,INM2,ITP,IBLK,RSTA(1Ø,3),NBR,BI,TPFC,TEIHC,
  +        TRIHC,TSKOC,TCOST,OSPRO,BO,ENIN(5Ø),PRFL(5Ø),
  +        RIC(5Ø),EIC(5Ø),SOC(5Ø),TCW(5Ø),EI,PDCOST,XAD,XPRD,
  +        XENI,XPRFL,XRIC,XEIC,XSOC,XTCW,XDMD,SAD,SPRD,
  +        SENI,SPRFL,SEIC,SSOC,STCW,SDMD
   WRITE(4,9ØØ)
   WRITE(4,1ØØØ)
   N = NBR + 4
   WRITE(4,1Ø1Ø) NBR,N,INM1,INM2,ISN
   WRITE(4,1Ø2Ø)
    SAD=SPRD=SENI=SPRFL=SRIC=SEIC=SSOC=STCW=SDMD=Ø
   XAD=XPRD=XENI=XPRFL=XRIC=XEIC=XSOC=XTCW=XDMD=Ø
   DO 12 K=NBR,N
   XAD=XAD+DMD(K)
   XPRD=XPRD+PRPL(K)
   XENI=XENI+ENIN(K)
   XPRFL=XPRFL+PRFL(K)
   XRIC=XRIC+RIC(K)
   XEIC=XEIC+EIC(K)
   XSOC=XSOC+SOC(K)
   XTCW=XTCW+TCW(K)
   II=K+5
12 XDMD=XDMD+DMDNR(II)
   XAD=XAD/5
   XPRD=XPRD/5
   XENI=XENI/5
   XPRFL=XPRFL/5
   XRIC=XRIC/5
   XEIC=XEIC/5
   XSOC=XSOC/5
   XTCW=XTCW/5
   XDMD=XDMD/5
   DO 13 K=NBR,N
    SAD= SAD + (DMD(K) - XAD)**2
    SPRD = SPRD + (PRPL(K) - XPRD)**2
    SENI = SENI + (ENIN(K) - XENI)**2
    SPRFL = SPRFL + (PRFL(K) - XPRFL)**2
    SRIC = SRIC + (RIC(K) - XRIC)**2
    SEIC = SEIC + (EIC(K) - XEIC)**2
    SSOC = SSOC + (SOC(K) - XSOC)**2
    STCW = STCW + (TCW(K) - XTCW)**2
   II=K+5
13  SDMD = SDMD + (DMDNR(II) = XDMD)**2
   SAD=SQRT(SAD/5)
   SPRD=SQRT(SPRD/5)
   SENI=SQRT(SENI/5)
   SPRFL=SQRT(SPRFL/5)
   SRIC=SQRT(SRIC/5)
```

```
      SEIC=SQRT(SEIC/5)
      SSOC=SQRT(SSOC/5)
      STCW=SQRT(STCW/5)
      SDMD=SQRT(SDMD/5)
      IF((IBLK .GE. 13) .AND. (IBLK .L#. 16)) CALL GSD(PDCOST,
     +XAD,XPRD,XENI,XPRFL,XRIC,XEIC,XSOC,XTCW,XDMD,SAD,SPRD,SENI,
     + SPRFL,SRIC,SEIC,SSOC,STCW,SDMD)
      IF((IBLK .GE.5) .AND. (IBLK .LE. 8)) CALL TABSD(PDCOST,
     + XAD,XPRD,XENI,XPRFL,XRIC,XEIC,XSOC,XTCW,XDMD,SAD,SPRD,SENI,
     +  SPRFL,SRIC,SEIC, SSOC,STCW,SDMD)
      IF((IBLK .GE. 9) .AND. (IBLK .LE.12)) CALL GRD(NBR,ENIN,
     +   PRFL,RIC,EIC,SOC,TCW,PRPL,PDCOST,DMD,DMDNR,IBLK)
      IF((IBLK .GE. 1) .AND. (IBLK .LE 4)) CALL TABRD(NBR,ENIN,
     +   PRFL, RIC, EIC, SOC, TOCW, PROPRL,PDCOST,DMD,DMDNR,IBLK)
  9ØØ FORMAT(1H1,///)
 1ØØØ FORMAT(57X,*OPERATING RESULTS*,/)
 1Ø1Ø FORMAT(1HØ,45X,*FOR WEEKS *,I2,* - *,I2,* MANAGER  *,
     +      2A1Ø,X,I9,//)
 1Ø2Ø FORMAT(1HØ,13X,*- - - - - - - UNITS - - - - - *,
     +      *- - - - - - -*,8X,*- - - - - - - - - - - - - - - COSTS*
      RETURN
      END
      SUBROUTINE TABRD(NBR,ENIN,PRFL,RIC,EIC,SOC,TCW,
     +       PRPL,PRDCOST,DMD,DMDNR)
      DIMENSION ENIN(5Ø),PRFL(5Ø),RIC(5Ø),EIC(5Ø),SOC(5Ø),
     +       TCS(5Ø),PRPL(5Ø),DMD(5Ø),DMDNR(5Ø)
      WRITE(4,1Ø3Ø)
      WRITE(4,1Ø4Ø)
      N = NBR + 4
      DO 2Ø I = NBR, N
   2Ø WRITE(4,1Ø5Ø) I,DMD(I),PRPL(I),ENIN(I),PRFL(I)
     +       RIC(I),EIC(I),SOC(I),TCW(I)
      WRITE(4,1Ø6Ø) PDCOST
      WRITE(4,1Ø7Ø)
      WRITE(4,1Ø8Ø)
      WRITE(4,1Ø9Ø)
      J = NBR + 9
      N = NBR + 5
      DO 4Ø I = N,J
   4Ø WRITE(4,11ØØ) I,DMDNR(I)
 1Ø3Ø FORMAT(1HØ,25X,*ACTUAL*,5X,*NUMBER*, 7X,*ENDING*,7X,
     +      *PRODUCTION*,6X,*REGULAR*,8X,*EXTRA*,11X,*STOCK-*,
     +      6X,*TOTAL WEEKS*)
 1Ø4Ø FORMAT(1H ,14X,*WEEK*,7X,*DEMAND*,5X,*PRODUCED*,4X,
     +      *INVENTORY*,6X,*FLUCUATION*,5X,*INVENTORY*,5X,
            *INVENTORY*,1ØX,*OUTS*,1ØX,*COST*//)
 1Ø5Ø FORMAT(1H ,15X,I2,5X,F11.Ø,3X,F8.Ø,4X,F8.0,6X,F11.2,
     +      3X,F11.2,3X,F11.2,3X,F11.2,5X,F12.2,/)
 1Ø6Ø FORMAT(1HØ,93X,*TOTAL COST FOR THIS PERIOD*,F13.2,////)
 1Ø7Ø FORMAT(1HØ,1ØX,1Ø(3H- -))
 1Ø8Ø FORMAT(1HØ,48X,*DEMAND FORECAST FOR NEXT FIVE WEEKS*)
 1Ø9Ø FORMAT(1HØ,14X,*WEEK*,7X,*DEMAND*,//)
 11ØØ FORMAT(1H ,15X,I2,7X,F8.Ø,/)
      RETURN
```

```
      END
      SUBROUTINE FIXARY(NBR,XRAY,IARY,ARY)
      DIMENSION XRAY(5Ø),IARY(1Ø,5),ARY(1Ø),TEMP(1Ø),TEN(1Ø)
      DO 5 I=1,1Ø
      ARY(I) = Ø.
       DO 4 J=1,5
 4      IARY(I,J) = 1H
 5    CONTINUE
      N= NBR+4
      J = Ø
      DO 1Ø I= NBR,N
       J= J+1
1Ø    TEMP(J) = XRAY(I)
      JJ=Ø
      DO 15 I = 1,1Ø
      IF (TEMP(I) .NE. Ø.) JJ=1
15    CONTINUE
      IF (JJ .EQ. Ø) GO TO 8Ø
      COMP= TEMP(1)
      DO 2Ø I= 2.5
       IF (TEMP(I) .GE. COMP) COMP = TEMP(I)
2Ø    CONTINUE
      TEN(1Ø) = COMP
      TEN(1) = COMP/1Ø
      DO 25 I= 1,8
       IC=1Ø-I
25    TEN(IC) = IC*TEN(1)
      DO 7Ø I= 1,5
      NS1=Ø
       DO 6Ø J= 1,9
      IF(NS1 .NE. Ø) GO TO 6Ø
        II = J+1
        IF(TEMP(I) .GE. TEN(J)  .AND. TEMP(I) .LE. TEN(II)) GOT TO 45
        GO TO 6Ø
45      IP = 1Ø -J
      IF (ARY(IP)  .EQ. TEMP(I)) GO TO 6Ø
      IF (ARY(IP)  .GT. Ø.) GO TO 5Ø
        ARY(IP) = TEMP(I)
      NS1=1
      GO TO 6Ø
5Ø    L = IP
      TEMP1= TEMP(I)
      DO 55 M = 1,1Ø
      IF (L .GE. 1Ø) GO TO 55
      IF (TEMP1 .EQ. ARY(L)) GO TO 55
      IF (TEMP1 .GT. ARY(L)) GO TO 53
      GO TO 54
53    IP = L
      TEMP2 = ARY(L)
      ARY(L) = TEMP1
      TEMP1 = TEMP2
54    L = L+1
55    CONTINUE
```

```
6Ø CONTINUE
7Ø CONTINUE
   DO 76 MM=1,1Ø
   IF (ARY(MM) .NE. Ø.) GO TO 72
   GO TO 76
72 DO 74 NN= 1,5
   IF (TEMP(NN) .NE. ARY(MM)) GO TO 74
   DO 73 I=MM,1Ø
   IARY(I,NN) = 1HX
73 CONTINUE
74 CONTINUE
76 CONTINUE
8Ø DO 9Ø J = 1,5
9Ø IARY(1Ø,J) = 1HX
   RETURN
   END
   SUBROUTINE GRD(NBR,ENIN,PRFL,RIC,EIC,SOC,TCW,PRPL,PDCOST,
  +          DMD,DMDNR,IBLK)
    DIMENSION ARY1(1Ø),IARY1(1Ø,5),ARY2(1Ø),IARY2(1Ø,5),ARY3(1Ø),
  +     IARY3(1Ø,5),ARY4(1Ø),IARY4(1Ø,5),ARY5(1Ø),IARY5(1Ø,5),
  +     ARY6(1Ø),IARY6(1Ø,5),ARY7(1Ø),IARY7(1Ø,5),ARY8(1Ø),
  +     IARY8(1Ø,5),ARY9(1Ø),IARY9(1Ø,5)
   CALL FIXARY(NBR,DMD,IARY1,ARY1)
   CALL FIXARY(NBR,PRPL,IARY2,ARY2)
   CALL FIXARY(NBR,ENIN,IARY3,ARY3)
   CALL FIXARY(NBR,PRFL,IARY4,ARY4)
   CALL FIXARY(NBR,RIC,IARY5,ARY5)
   CALL FIXARY(NBR,EIC,IARY6,ARY6)
   CALL FIXARY(NBR,SOC,IARY7,ARY7)
   CALL FIXARY(NBR,TCW,IARY8,ARY8)
   N=NBR+5
   CALL FIXARY(N,DMDNR,IARY9,ARY9)
   WRITE(4,1ØØØ)
   WRITE(4,1Ø2Ø)
   DO 2Ø I=1,1Ø
   WRITE(4,1Ø3Ø) (ARY1(I),IARY1(I,1),IARY1(I,2),IARY1(I,3),
  +  IARY1(I,4),IARY1(I,5),ARY2(I),IARY2(I,1),IARY2(I,2),IARY2(I,3),
  +  IARY2(I,4),IARY2(I,5),ARY3(I),IARY3(I,1),IARY3(I,2),IARY3(I,3),
  +  IARY3(I,4),IARY3(I,5),ARY4(I),IARY4(I,1),IARY4(I,2),IARY4(I,3),
  +  IARY4(I,4),IARY4(I,5),ARY5(I),IARY5(I,1),IARY5(I,2),IARY5(I,3),
  +  IARY5(I,4),IARY5(I,5),ARY6(I),IARY6(I,1),IARY6(I,2),IARY6(I,3),
  +  IARY6(I.4),IARY6(I,5))
2Ø CONTINUE
   WRITE(4,1Ø4Ø)
   WRITE(4,1Ø5Ø)
   WRITE(4,1Ø6Ø)
   WRITE(4,1Ø7Ø)
   WRITE(4,11ØØ) PDCOST
   WRITE(4,1Ø75) (ARY7(1),IARY7(1,1),IARY7(1,2),IARY7(1,3),
  +  IARY7(1,4),IARY7(1,5),ARY8(1),IARY8(1,1),IARY8(1,2),IARY8(1,3),
  +  IARY8(1,4),IARY8(1,5),ARY9(1),IARY9(1,1),IARY9(1,2),IARY9(1,3),
  +  IARY9(1,4),IARY9(1,5))
   DO 4Ø I = 2,1Ø
   WRITE(4,1Ø8Ø) (ARY7(I),IARY7(I,1),IARY7(I,2),IARY7(I,3),
```

```
     +  IARY7(I,4),IARY7(I,5),ARY8(I),IARY8(I,1),IARY8(I.2),IARY8(I,3),
     +  IARY8(I.4),IARY8(I,5),ARY9(I),IARY9(I,1),IARY9(I,2),IARY9(I,3),
     +  IARY9(I,4),IARY9(I,5)
   4Ø CONTINUE
      WRITE(4,1Ø9Ø)
1ØØØ FORMAT(1HØ,8X,*ACTUAL*,15X,*NUMBER*,14X,*ENDING*,15X,
     +      *PRODUCTION*,15X,*REGULAR*,16X,*EXTRA*)
1Ø2Ø FORMAT(1H ,8X,*DEMAND*,15X,*PRODUCED*,12X,*INVENTORY*,12X,
     +      *FLUCUATION*,15X,*INVENTORY*,14X,*INVENTORY*,//)
1Ø3Ø FORMAT(1H ,2(F8.Ø,X,5(A1,X),2X),F8.Ø,X,5(A1,X),3(F11.Ø,X,
     +      5(A1,X),X))
1Ø4Ø FORMAT(1H ,*WEEK*,5X,1ØH1 2 3 4 5 ,2(11X,1ØH1 2 3 4 5),
     +      12X,1ØH1 2 3 4 5 ,13X,1ØH1 2 3 4 5 ,13X,9H1 2 3 4 5,///)
1Ø5Ø FORMAT(1HØ,1Ø(2H- ),*COST *,1Ø(2H- ),1ØX,18(2H- ))
1Ø6Ø FORMAT(1HØ,1ØX,*STOCK-*,18X,*TOTAL WEEKS*,9X,
     +      *TOTAL COST FOR*,1ØX,*DEMAND FORECAST FOR NEXT FIVE WEEKS*)
1Ø7Ø FORMAT(1H ,1ØX,*OUTS*,23X,*COST*,13X*THIS  PERIOD*,//)
1Ø75 FORMAT(1H+,2(F11.2,X,5(A1,X),2X),36X,F11.Ø,f(A1,X))
1Ø8Ø FORMAT(1HB,2F(11.2,X,5(A1,X),2X),36X,F11.Ø,5(A1,X))
1Ø9Ø FORMAT(1H ,*WEEK*,8X,1ØH1 2 3 4 5 ,14X,1OH1 2 3 4 5 ,
     +      49X,1ØH1 2 3 4 5 )
11ØØ FORMAT(1HØ,53X,F13.2)
      RETURN
      END
      SUBROUTINE TABSD(PDCOST,XAD, XPRD, XENI, XPRFL, XRIC,
     +    XEIC,XSOC,STCW,SDMD,SAD,SPRD,SENI,SPRFL,SRIC,
     +    SEIC,SSOC,STCW,SDMD)
      WRITE(4,1Ø3Ø)
      WRITE94,1Ø4Ø)
      WRITE(4,1Ø5Ø) XAD,XPRD,XENI,XPRFL,XRIC,XEIC,XSOC,XTCW
      WRITE(4,1Ø51)
      WRITE(4,1Ø52) SAD, SPRD, SENI, SPRFL, SRIC, SEIC, SSOC,STCW
      WRITE (4,1Ø6Ø) PDCOST
      WRITE(4,1Ø7Ø )
      WRITE(4,1Ø8Ø)
      WRITE(4,11ØØ) XDMD
      WRITE(4,11Ø1)
      WRITE(4,11Ø2) SDMD
1Ø3Ø FORMAT(1HØ,25X,*ACTUAL*,5X,*NUMBER*,7X,*ENDING*,7X,
     +      *PRODUCTION*,6X,*REGULAR*,8X,*EXTRA*,9X,*STOCK-*,
     +      8X,*TOTAL WEEKS*)
1Ø4Ø FORMAT(1HØ,25X,*DEMAND*,5X,*PRODUCED*,4X
     +      *INVENTORY*,5X,*FLUCUATION*,6X,*INVENTORY*,4X
     +      *INVENTORY*,6X,*OUTS*,12X,*COST*,//)
1Ø5Ø FORMAT(1H ,6X,*MEAN*,1ØX,F11.2,3X,F9.2,4X,F9.2,5X,F11.2,
     +      4X,F11.2,2X,F11.2,3X,F11.2,6X,F12.2,//)
1Ø6Ø FORMAT(1HØ,93X,*TOTAL COST FOR THIS PERIOD*,F13.2,////)
1Ø7Ø FORMAT(1HØ,1ØX,1Ø(3H- -))
1Ø8Ø FORMAT(1HØ,48X,*DEMAND FORECAST FOR NEXT FIVE WEEKS*)
1Ø51 FORMAT(1H ,6X,*STANDARD*)
1Ø52 FORMAT(1H ,6X,*DEVIATION*,5X,F11.2,4X,F8.2,5X,F8.2,5X,
     +      F11.2,4X,F11.2,2X,F11.2,3X,F11.2,6X,F12.2,//)
11ØØ FORMAT(1H ,6X,*MEAN*,5X,F11.2,//)
```

```
 11Ø1 FORMAT(1H ,6X,*STANDARD*)
 11Ø2 FORMAT(1H ,6X,*DEVIATION*,F11.2)
      RETURN
      END
      SUBROUTINE GSD(PDCOST,XAD,XPRD.XENI,XPRFL,XRIC,XEIC,XSOC,
     + XTCW,XDMD,SAD,SPRD,SENI,SPRFL,SRIC,SEIC,SSOC,STCW,SDMD)
      DIMENSION ARY1(1Ø),IARY1(1Ø,2),ARY2(1Ø),IARY2(1Ø,2),ARY3(1Ø),
     + IARY3(1Ø,2),ARY4(1Ø),IARY4(1Ø,2),ARY5(1Ø),IARY5(1Ø,2),
     + ARY6(1Ø),IARY6(1Ø,2),ARY7(1Ø),IARY7(1Ø,2),ARY8(1Ø),
     + IARY8(1Ø,2),ARY9(1Ø),IARY9(1Ø,2)
      WRITE (4,1Ø3Ø)
      WRITE(4,1Ø4Ø)
      CALL FIXARY2(XAD,SAD,ARY1,IARY1)
      CALL FIXARY2(XPRD,SPRD,ARY2,IARY2)
      CALL FIXARY2(XENI,SENI,ARY3,IARY3)
      CALL FIXARY2(XPRFL,SPRFL,ARY4,IARY4)
      CALL FIXARY2(XRIC,SRIC,ARY5,IARY5)
      CALL FIXARY2(XEIC,SEIC,ARY6,IARY6)
      CALL FIXARY2(XSOC,SSOC,ARY7,IARY7)
      CALL FIXARY2(STCW,STCW,ARY8,IARY8)
      CALL FIXARY2(XDMD,SDMD,ARY9,IARY9)
      DO 3Ø I=1,1Ø
      WRITE(4,1Ø5Ø) ARY1(I),IARY1(I,1),IARY1(I,2),ARY2(I),
     + IARY2(I,1),IARY2(I,2),ARY3(I),IARY3(I,1),IARY3(I,2),
     + ARY4(I),IARY4(I,1),IARY4(I,2),ARY5(I),IARY5(I,1),
     + IARY5(I,2),ARY6(I),IARY6(I,1),IARY6(I,2),ARY7(I),
     + IARY7(I,1),IARY7(I,2)
   3Ø CONTINUE
      WRITE(4,1Ø6Ø)
      WRITE(4,1Ø7Ø)
      WRITE(4,1Ø8Ø)
      WRITE(4,1Ø9Ø)
      WRITE(4,11ØØ)
      WRITE(4,111Ø)
      WRITE(4,112Ø)
      WRITE(4,1125) PDCOST
      WRITE(4,1128) ARY8(1),IARY8(1,1),IARY8(1,2),
     + ARY9(1),IARY9(1,1),IARY9(1,2)
      DO 4Ø I=2,1Ø
      WRITE(4,113Ø) ARY8(I),IARY8(I,1),IARY8(I,2),ARY9(I),
     + IARY9(I,1),IARY9(I,2)
   4Ø CONTINUE
      WRITE(4,113Ø)
      WRITE(4,114Ø)
      WRITE(4,115Ø)
      WRITE(4,116Ø)
      WRITE(4,117Ø)
1Ø3Ø FORMAT(1HØ,7X,*ACTUAL*,11X,*NUMBER*,9X,*ENDING*,13X,
     + *PRODUCTION*,12X,*REGULAR*,16X,*EXTRA*,11X,*STOCK-*)
1Ø4Ø FORMAT(1H ,7X,*DEMAND*,1ØX,*PRODUCED*,8X,*INVENTORY*,
     + 1ØX,*FLUCUATION*,12X,*INVENTORY*,12X,*INVENTORY*,
     + 9X,*OUTS*,//)
1Ø5Ø FORMAT(1H ,F11.Ø,1X,A1,2X,A1,2X,F9.Ø,1X,A1,2X,A1,2X,
```

```
     + F9.Ø,1X,A1,2X,A1,4X,F11.Ø,1X,A1,2X,A1,4X,F11.Ø,1X,
     + A1,2X,A1,3X,F11.Ø,1X,A1,2X,A1,3X,F11.Ø,1X,A1,2X,A1)
1Ø6Ø FORMAT(1HØ,12X,*M*,2X,*S*,12X,*M*,2X,*S*,12X,*M*,
     + 2X,*S*,16X,*M*,2X,*S*,16X,*M*,2X,*S*,15X,*M*,2X,*S*
     + 15X,*M*,2X,*S*)
1Ø7Ø FORMAT(1H ,12X,*E*,2X,*D*,12X,*E*,2X,*D*,12X,*E*,
     + 2X,*D*,16X,*E*,2X,*D*,16X,*E*,2X,*D*,15X,*E*,2X,
     + *D*,15X,*E*,2X,*D*)
1Ø8Ø FORMAT(1H ,12X,*A*,15X,*A*,15X,*A*,19X,*A*,19X,*A*,
     + 18X,*A*,18X,*A*)
1Ø9Ø FORMAT(1H ,12X,*N*,15X,*N*,15X,*N*,19X,*N*,19X,*N*,
     + 18X,*N*,18X,*N*,//)
11ØØ FORMAT(1HØ,1Ø(2H- ),*COST*,14(2H- ),15X,2Ø(2H- ),
     + *UNITS*,9(2H- ),/)
111Ø FORMAT(1HØ,5X,*TOTAL WEEKS*,13X,*TOTAL COST FOR*,
     + 25X,*DEMAND FORECAST FOR NEXT FIVE WEEKS*)
112Ø FORMAT(1H ,9X,*COST*,18X,*THIS PERIOD*,//)
1125 FORMAT(1H ,29X,F13.2)
1128 FORMAT91H+,F12.Ø,1X,A1,2X,A1,61X,F12.Ø,1X,A1,2X,A1)
113Ø FORMAT(1H ,F12.Ø,1X,A1,2X,A1,61X,F12.Ø,1X,A1,2X,A1)
114Ø FORMAT(1H ,13X,*M*,2X,*S*,74X,*M*,2X,*S*)
115Ø FORMAT(1H ,13X,*E*,2X,*D*,74X,*E*,2X,*D*)
116Ø FORMAT(1H ,13X,*A*,77X,*A*)
117Ø FORMAT(1H ,13X,*N*,77X,*N*)
      RETURN
      END
      SUBROUTINE FIXARY2(XMN,SD,ARY,IARY)
      DIMENSION ARY(1Ø),IARY(1Ø,2),TEN(1Ø)
      DO 5 I=1,1Ø
      ARY(I)= Ø
      DO 4 J=1,2
    4 IARY(I,J) = 1H
    5 CONTINUE
      IF (XMN .EQ. Ø.) GO TO 6Ø
      I1 = 2
      I2=1
      IF (SD .GT. XMN) GO TO 52
   1Ø SXN=XMN
      SSD=SD
   15 TEN(1Ø) = SXN
      TEN(1) = SXN/1Ø.
      DO 2Ø I = 1,8
      IC = 1Ø -I
   2Ø TEN(IC) = IC * TEN(1)
      IF(TEN(1) .GT. SSD) TEN(1)= SSD - 1
      J = 1
      IS = Ø
      DO 3Ø I = 1,9
      IF (IS .NE. Ø) GO TO 35
      J = J+1
      IF (SSD .GE. TEN(I)  .AND. SSD .LE. TEN(J)) GO TO 25
      GO TO 3Ø
   25 IP = 1Ø - J
```

```
      IF((J .EQ. 1Ø)  .OR. (IP .EQ. 1)) IP=2
      ARY(IP) = SSD
      IS = 1
   3Ø CONTINUE
   35 ARY(1) = SXN
      IF (SSD .EQ. Ø.Ø) GO TO 42
      DO 4Ø I = IP,1Ø
   4Ø IARY(I,I1)= 1HX
   42 DO 5Ø I =1,1Ø
   5Ø IARY(I,I2) = 1HX
      GO TO 6Ø
   52 SSD=XMN
      SXN = SD
      I1=1
      I2=2
      GO TO 15
   6Ø RETURN
      END
      SUBROUTINE UPDT(NIAW,IBLKW,DT,DC)
      COMMON PRPL(5Ø),DMDNR(5Ø),DMD(5Ø),CPCG,CEXI,CSKO,CRI,
     +       ISN,INM1,INM2,ITP,IBLK,RSTA(kØ.3),NBR,BI,TPFC,TEIHC,TRIHC,
     +       TSKOC,TCOST,OSPRO,BO,ENIN(5Ø),PRFL(5Ø),RIC(5Ø),
     +       EIC(5Ø),SOC(50),TCW(5Ø),EI
      N = (NBR-1)/5
      RSTA(N,1) = TCOST
      RSTA(N,2) = DT
      RSTA(N,3) = DC
      WRITE(8,4ØØØ) ISN,INM1,INM2,ITP,IBLK
      WRITE(14,4Ø1) ((RSTA(I,J),J=1,3),I=1,1Ø)
      WRITE(1Ø,4Ø1Ø) NIAW,IBLKW,NBR,BI,TPFC,TRIHC,TEIHC,
     +      TSKOC,TCOST,BO,OSPRO
4ØØØ FORMAT(I9,2A1Ø,A4,I2)
4Ø01 FORMAT(8(F12.2,F4.Ø,F3.Ø))
4Ø1Ø FORMAT(I9,I2,I2,F8.Ø,5F1Ø.2,2F8.Ø)
      END
      SUBROUTINE ATEND(TCOST)
      WRITE(6,1ØØØ) TCOST
      WRITE(6,1Ø01)
1ØØØ FORMAT(1H1,*CONGRATULATIONS, YOU HAVE COMPLETED THE GAME. *,
    + *YOU HAVE A TOTAL OPERATING COST  OF *,F12.2,* DOLLARS. *)
1Ø01 FORMAT(* THANK YOU FOR PARTICIPATING.  ENJOY THE PARTY.*)
      END
      SUBROUTINE RAN(M1,M2,X)
      M2=M1*122Ø7Ø3125
      IF(M2) 1,2,2
    1 M2 =M2+214783647+1
    2 X=M2*Ø.4656613E-9
      N=INT(X)
      X=X-N
      M1=M2
      RETURN
      END
```

APPENDIX B

INPUT ROUTINE

```
      PROGRAM CREATE(INPUT,OUTPUT,DECS,TAPE5=INPUT,TAPE6=OUTPUT,
     +      TAPE7=DECS)
      COMMON ISN,DT,DC,PRPL
      DIMENSION PRPL(5)
      DATA ICOMP/1HY/,NY/1HY/
      WRITE(6,12Ø)
12Ø   FORMAT(*AT THE NEXT >, ENTER YOUR SOCIAL SECURITY NUMBER*)
      READ(5,13Ø) ISN
13Ø   FORMAT(I9)
      WRITE(6,22Ø)
22Ø   FORMAT(*AT THE NEXT >, ENTER THE TIME IT TOOK YOU TO MAKE*
     +      * THE DECISION, IN MINUTES.  EXAMPLE:  IF IT TOOK YOU 2Ø*
     +      * MINUTES YOU WOULD ENTER >2Ø*)
      READ(5,*) DT
 1Ø   WRITE(6,18Ø)
18Ø   FORMAT(*AT THE NEXT >, ENTER THE LEVEL OF CONFIDENCE YOU *
     +      *HAVE IN YOUR DECISION ,(1 - 1Ø), *)
      READ(5,*) DC
      IF(DC.LT.1 .OR. DC.GT.1Ø) GO TO 1Ø
      WRITE(6,245)
245   FORMAT(*ENTER YOUR PRODUCTION DECISION FOR THE APPROPRIATE*
     +       * WEEK WHEN THE QUESTION MARK(>) APPEARS.  YOUR PLANT*,
     + * HAS A CAPACITY OF 18ØØØØ UNITS PER WEEK.*)
      DO 5Ø I=1,5
 2Ø   WRITE(6,25Ø) I
25Ø   FORMAT(*WEEK  *,I1)
       READ(5,*) PRPL(I)
26Ø   FORMAT(F6.Ø)
      IF(PRPL(I) .LT.Ø .OR. PRPL(I) .GT. k8ØØØØ) GO TO 2Ø
 5Ø   CONTINUE
      WRITE(6,31Ø)
31Ø   FORMAT(*DO YOU WANT TO REVIEW THE VALUES YOU HAVE INPUT>  IF SO*,
     +  * ENTER YES WHEN A > APPEARS. IF NOT, ENTER NO.*)
      READ(5,32Ø) IY
32Ø   FORMAT(A1)
315   IF(IY .EQ. ICOMP) CALL CHECK(NY)
      IF(NY .NE. ICOMP) CALL FIXIT(IY)
      IF(IY.EQ.ICOMP .AND. NY.NE.ICOMP) GO TO 315
      WRITE(7,3ØØ) ISN,DT,DC,(PRPL(I),I=1,5)
3ØØ    FORMAT(I9,F4.Ø,F3.Ø,5F8.Ø)
      END
      SUBROUTINE  CHECK(IY)
      COMMON ISN,DT,DC,PRPL(5)
      DATA ICOMP/1HY/
      WRITE(6,1ØØ) ISN
1ØØ   FORMAT(*SOCIAL SECURITY NR. = *, I9)
      WRITE(6,1Ø2) DT
1Ø2   FORMAT(*DECISION TIME = *, F4.Ø)
      WRITE(6,1Ø3) DC
1Ø3   FORMAT(*DECISION CONFIDENCE = *,F3.Ø)
      DO 3Ø I=1,5
 3Ø   WRITE(6,1Ø4) I,PRPL(I)
1Ø4   FORMAT(*PRODUCTION FOR WEEK *,I1,* = *,F8.Ø)
```

```
    WRITE(6,2ØØ)
2ØØ FORMAT(*IF YOUR INPUT IS CORRECT, ENTER YES WHEN THE *,
   + *> APPEARS.  *,/,*IF NOT, THEN ENTER NO.  *)
    READ(5,3ØØ) IY
3ØØ FORMAT(A1)
    RETURN
    END
    SUBROUTINE FIXIT(IY)
    COMMON ISN,DT,DC,PRPL(5)
    DATA ICOMP/1HY/
    WRITE(6,5Ø)
 5Ø FORMAT(*ENTER THE FOLLOWING TO CORRECT YOUR INPUT: *,/,
   + *1 FOR SOCIAL SECURITY NR., 2 FOR DECISION TIME*,/,
   + *3 FOR DECISION CONFIDENCE, AND 4 FOR PRODUCTION AMOUNT*)
    READ(5,6Ø) IX
 6Ø FORMAT(I1)
1ØØ IF(IX .EQ. 1) GO TO 2ØØ
    IF (IX .EQ. 2) GO TO 3ØØ
    IF (IX .EQ. 3) GO TO 4ØØ
    WRITE(6,5ØØ)
5ØØ FORMAT(*ENTER 1 TO CORRECT WEEK 1 PRODUCTION, 2 TO *,
   + *CORRECT WEEK 2, AND SO ON *,/,*TO A 5 TO CORRECT WEEK 5*)
    READ(5,6ØØ)  I
6ØØ FORMAT(I1)
15Ø WRITE(6,61Ø) I
61Ø FORMAT(*ENTER THE CORRECT AMOUNT OF PRODUCTION FOR WEEK *,I1)
    READ(5,*) PRPL(I)
    WRITE(6,63Ø)
63Ø FORMAT(*IF YOU WISH TO CORRECT MORE PRODUCTION DECISIONS*,
   + * ENTER THE NUMBER OF THE WEEK TO BE CORRECTED WHEN*,
   + /,* THE > APPEARS.  IF NOT, ENTER A Ø (ZERO).*)
    READ(5,64Ø) I
64Ø FORMAT(I1)
    IF(I .GT. Ø) GO TO 15Ø
645 WRITE(6,65Ø)
65Ø FORMAT(*IF YOU NEED TO MAKE ANY MORE CORRECTIONS OR REVIEW*,
   + * YOUR INPUT, ENTER Y *,
   + *OTHERWISE ENTER N.*)
    READ(5,66Ø) IY
66Ø FORMAT(A1)
    GO TO 9ØØ
2ØØ WRITE(6,21Ø)
21Ø FORMAT(*ENTER CORRECT SOC. SEC. NR.*)
    READ (5,22Ø) ISN
22Ø FORMAT(I9)
    GO TO 645
3ØØ WRITE(6,31Ø)
31Ø FORMAT(*ENTER CORRECT DECISION TIME*)
    READ(5,*) DT
    GO TO 645
4ØØ WRITE (6,41Ø)
41Ø FORMAT(*ENTER CORRECT DECISION CONFIDENCE LEVEL*)
    READ(5,*) DC
```

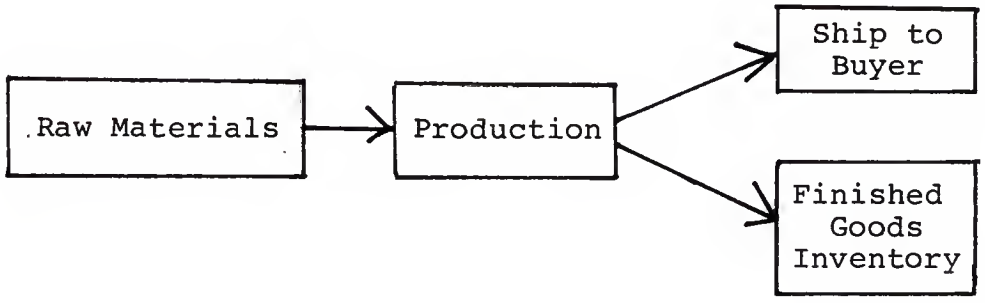
```
      GO TO 645
900   CONTINUE
      END
```

APPENDIX C

INSTRUCTIONS FOR USING SIMPRO

INSTRUCTIONS FOR OPERATIONS MANAGER

Simpro, Inc., is a manufacturing firm producing a single product, Simplex, a protein substitute. The firm uses raw materials, of which it has an unlimited supply, to produce Simplex. The finished product is either shipped to a buyer or held in finished goods inventory for later sale in response to the actual demand, as shown below:



You have been hired as operations manager for Simpro. As the operations manager, your task is to develop a production plan to minimize the total costs of production for a fifty-week period. Your fifty-week total production time will be broken up into ten runs of five weeks each, i.e., weeks 1-5 will be the first run, weeks 6-10 the second, etc.

Some conditions prevailing at Simpro which might affect your decisions as operations manager are:

1. Actual demand for the product averages 100,000 units per week, but demand is uncertain and

fluctuates. Historically, demand has ranged from 79,000 to 181,000 units per week. Demand has also shown a seasonal pattern. As part of the report prepared for you at the end of each five weeks' run, you will be given a demand forecast for each week of the next run. Marketing has determined that for weeks 1-5 the demand is:

Week	Demand
1	100,000
2	95,000
3	82,000
4	73,000
5	65,000

2. The production capacity of Simpro is 180,000 units per week. Therefore, you may produce from 0 to 180,000 units each week to satisfy demand. You may change the amount produced each week, but it will cost $0.10/unit for the amount of change. This cost is for adjustments to the production equipment and personnel if changes are made from the week before. These costs are referred to as production fluctuation costs.

3. Simpro has a finished goods inventory capacity of 240,000 units. The cost for storing units of Simplex in company-owned storage is $0.04 per unit (regular inventory holding cost). However, if you have to store more than 240,000 units, you will have to rent extra inventory space at the rate of $0.08 per unit (extra inventory holding cost).

4. When a week's production plus finished goods inventory isn't sufficient to satisfy demand, shortages or stock-outs result. The shortage is carried over into the next and succeeding weeks until satisfied. There is a cost due to loss of customer goodwill, lost sales, etc., resulting from the stock-outs. The rate of the stock-out cost is $0.25 per unfilled unit.

Top management will base their evaluation of your performance on the total cost of the fifty weeks' production run. Total cost is the sum of the above-mentioned costs:

TOTAL COST = Production fluctuation cost
+ Regular inventory holding cost
+ Extra inventory holding cost
+ Stock-out cost

Your objective, then, is to minimize the total cost, that is, to balance the costs to avoid excessive costs in each area. You will have the opportunity to adjust production for each five-week run.

Running the Game

The computer simulation is conducted in the following manner:

1. Determine the number of Simplex units to produce each week for the current five weeks' run. (Use the forecast given in this handout for the 1st run.)

2. Determine the level of confidence you have in your decisions based on a scale 1-10. A confidence rating of 1 would imply the lowest confidence and a rating of 10 the highest confidence. Also determine the amount of time it took you to make your decisions (in minutes) measured from the time you received the forecast for the next five weeks.

3. Use the computer terminal for the steps 3a-3g.
   Note: RET means carriage return or press the return key.
   (The terminal will be on when you begin.)

   (a) When requested, enter your seven-digit job number and RET.

   (b) When requested, enter your password and RET.

   (c) If the reply on the screen is: "IMPROPER LOG-IN", ask the assistant for help.

   (d) If the reply on the screen is:
   "TERMINAL XXX"
   "DO YOU WISH TO RECOVER"

   You type: "NO" and RET

   (e) A "/" will appear on the screen.

   You type: G, SIMP, and RET

   (f) Again a "/" will appear on the screen.

   You type: SIMP and RET

   (g) Now the simulation has begun. When requested on the screen, type in your:

   (1) Social Security number and RET
   (2) Amount of time it took to make your decisions (in minutes) and RET
   (3) Production amounts for weeks as requested and RET
   (4) Level of confidence you have in your decisions

4. The program will simulate your production, and when finished will tell you to pick up your production report at the College of Business printer.

5. A laboratory assistant will provide you with your production report. You should analyze it and make your decisions for the next run. To make another run, start at step 3f.

6. Initially you will be allowed to practice on the terminal and run the simulator for three runs (15 weeks). After that "trial run", notify the assistant; he will reset the game. Then begin with week 1 again and manage the company for fifty weeks.

7. After you have completed your tenth run, your output will be collected. Then you will be given a short questionnaire to complete.

If you make an error or have any questions, ask the laboratory assistant for help.

When you are ready, notify the laboratory assistant and begin.

APPENDIX D

EXAMPLES OF SIMPRO OUTPUT

OPERATING RESULTS — TABULAR - RAW DATA

FOR WEEKS 1 - 5 MANAGER DAVIS, DONALD L. 576289130

WEEK	ACTUAL DEMAND	NUMBER PRODUCED	ENDING INVENTORY	PRODUCTION FLUCTUATION	REGULAR INVENTORY	EXTRA INVENTORY	STOCK OUTS	TOTAL WEEKS COST
	UNITS			COSTS				
1	115554	180000	64446	0.00	1288.92	0.00	0.00	1288.92
2	128725	160000	9572Ø	2000.00	1914.41	0.00	0.00	3914.41
3	134500	150000	11113Ø	1000.00	2222.61	0.00	0.00	3222.61
4	13174Ø	130000	109391	2000.00	2187.81	0.00	0.00	4187.81
5	12062	130000	118788	0.00	2375.77	0.00	0.00	2375.77
						TOTAL COST FOR THIS PERIOD		14989.52

DEMAND FORECAST FOR NEXT FIVE WEEKS

WEEK	DEMAND
6	106000
7	92000
8	82019
9	79000
10	84019

OPERATING RESULTS

FOR WEEKS 1 - 5 MANAGER DAVIS, DONALD L. 576289130

GRAPHICAL - RAW DATA

UNITS

ACTUAL DEMAND

```
134500      X
131740      X X
128725    X X X
120602    X X X X
115554  X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
WEEK    1 2 3 4 5
```

NUMBER PRODUCED

```
180000  X
160000  X X
150000  X X X
130000  X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
        1 2 3 4 5
```

ENDING INVENTORY

```
118788          X
111130        X X
109391        X X X
 9572Ø      X X X X
64446  X X X X X
     Ø X X X X X
     Ø X X X X X
     Ø X X X X X
     Ø X X X X X
       1 2 3 4 5
```

COSTS

PRODUC FLUCT

```
2000    X   X
   Ø    X   X
   Ø    X   X
   Ø    X   X
   Ø    X   X
1000    X X X
   Ø    X X X
   Ø    X X X
   Ø    X X X
   Ø  X X X X X
     1 2 3 4 5
```

REGULAR INVENT

```
2376          X
2223        X X
2188        X X X
1914    X X X X
1289  X X X X X
   Ø X X X X X
   Ø X X X X X
   Ø X X X X X
   Ø X X X X X
   Ø X X X X X
     1 2 3 4 5
```

EXTRA INVENT

```
Ø
Ø
Ø
Ø
Ø
Ø
Ø
Ø
Ø
Ø X X X X X
  1 2 3 4 5
```

STOCK-OUTS

```
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ
Ø.ØØ X X X X X
WEEK 1 2 3 4 5
```

TOTAL WEEKS COST

```
4187.81        X
3914.41    X   X
3222.61    X X X
   Ø.ØØ    X X X
2375.77    X X X X
   Ø.ØØ    X X X X
1288.92  X X X X X
   Ø.ØØ  X X X X X
   Ø.ØØ  X X X X X
   Ø.ØØ  X X X X X
     1 2 3 4 5
```

TOTAL COST FOR THIS PERIOD

14989.52

DEMAND FORECAST FOR NEXT FIVE WEEKS

```
133000      X
129981      X X
127981    X X X
120000    X X X X
116000  X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
      Ø X X X X X
WEEK    1 2 3 4 5
```

TABULAR - SSD

OPERATING RESULTS

FOR WEEKS 1 - 5 MANAGER DAVIS, DONALD L. 576289130

	UNITS			COSTS				
	ACTUAL DEMAND	NUMBER PRODUCED	ENDING INVENTORY	PRODUCTION FLUCTUATION	REGULAR INVENTORY	EXTRA INVENTORY	STOCK OUTS	TOTAL WEEKS COST
MEAN	126242.34	150000.00	99895.13	1000.00	1997.90	0.00	0.00	2997.90
STANDARD DEVIATION	7100.98	18973.67	19221.99	894.43	384.44	0.00	0.00	1059.63
					TOTAL COST FOR THIS PERIOD			14989.50

DEMAND FORECAST FOR NEXT FIVE WEEKS

MEAN	125392.32
STANDARD DEVIATION	6370.61

OPERATING RESULTS

GRAPHICAL - SSD

FOR WEEKS 1 - 5 MANAGER DAVIS, DONALD L. 576289130

UNITS			COSTS				
ACTUAL DEMAND	NUMBER PROD	END INVEN	PROD FLUC	REG INVEN	EXT INVEN	STOCK-OUTS	TOT WKS CST
126242 X	150000 X	99895 X	1000 X	1995 X	0	0	2998 X
0 X	0 X	0 X	894 X X	0 X	0	0	0 X
0 X	0 X	0 X	0 X X	0 X	0	0	0 X
0 X	0 X	0 X	0 X X	0 X	0	0	0 X
0 X	0 X	0 X	0 X X	0 X	0	0	0 X
0 X	0 X	0 X	0 X X	0 X	0	0	1062 X X
0 X	0 X	0 X	0 X X	0 X	0	0	0 X X
7101 X X	18974 X X	19222 X X	0 X X	384 X X	0	0	0 X X
0 X X	0 X X	0 X X	0 X X	0 X X	0	0	0 X X
0 X X	0 X X	0 X X	0 X X	0 X X	0	0	0 X X
MEAN SD	MEAN SD	MEAN SD	MEAN SD	MEAN SD	MEAN SD	MEAN SD	MEAN SD

TOTAL COST FOR THIS PERIOD

14989.52

DEMAND FORECAST FOR NEXT FIVE WEEKS - 125392 X

0 X

0 X

0 X

0 X

0 X

6371 X X

0 X X

0 X X

MEAN SD

APPENDIX E

TASK STRUCTURE RATING INSTRUMENT

TASK STRUCTURE RATING INSTRUMENT

I. Please consider the structure of the task represented in the attached "Instructions for Operations Manager", "Running the Game", and "Report Examples", for subjects acting in the role of an operations manager in a computer simulated environment.

II. Circle the appropriate number for the ranking of the task structure on a scale of 1-5 for the following dimensions:

A. To what degree are the goals of the production task clearly stated or made known to the subject?

1. To a very small degree
2. To a small degree
3. To some degree
4. To a great degree
5. To a very great degree

B. To what degree can the problems experienced in completing the production task be solved, using a variety of procedures? (Number of different paths to completing the task, number of alternatives for solution, number of different ways that the task can be completed.)

1. To a very small degree
2. To a small degree
3. To some degree
4. To a great degree
5. To a very great degree

C. To what degree could the correctness of the decisions required of the subject be verified in an organizational setting?

1. To a very small degree
2. To a small degree
3. To some degree
4. To a great degree
5. To a very great degree

D. To what degree is there more than one "correct solution" in the task? (Some tasks, such as arithmetic problems, have only one acceptable solution, while some, such as human relations problems, have an almost infinite number of solutions.)

1. To a very small degree
2. To a small degree
3. To some degree
4. To a great degree
5. To a very great degree

APPENDIX F

POST-EXPERIMENTAL QUESTIONNAIRE

POST-EXPERIMENTAL QUESTIONNAIRE

Please respond to the following questions by writing the letter of your response in the space to the left of the question and by filling in the blanks, if appropriate.

_____1. Given a choice of the following reports, which would you have preferred for use in completing the production task in the experiment?

a. Report using tabular format and raw data level of summarization, for example:

OPERATING RESULTS
FOR WEEKS 1-5 MANAGER_____

	UNITS			COSTS				
WEEK	ACTUAL DEMAND	PROD	ENDING INV	PROD FLUX	REG INV	EXTRA INV	STCK OUTS	TOTAL WEEKS COST
1	108721	100000	91279	0	1826	0	0	1826
2	94804	100000	96475	0	1929	0	0	1929
3	83038	102137	115574	214	2311	0	0	2525
4	67814	103366	151126	123	3023	0	0	3145
5	64743	103917	190301	55	3806	0	0	3861

TOTAL COST FOR THIS PERIOD 13286
TOTAL COST TO DATE 13286

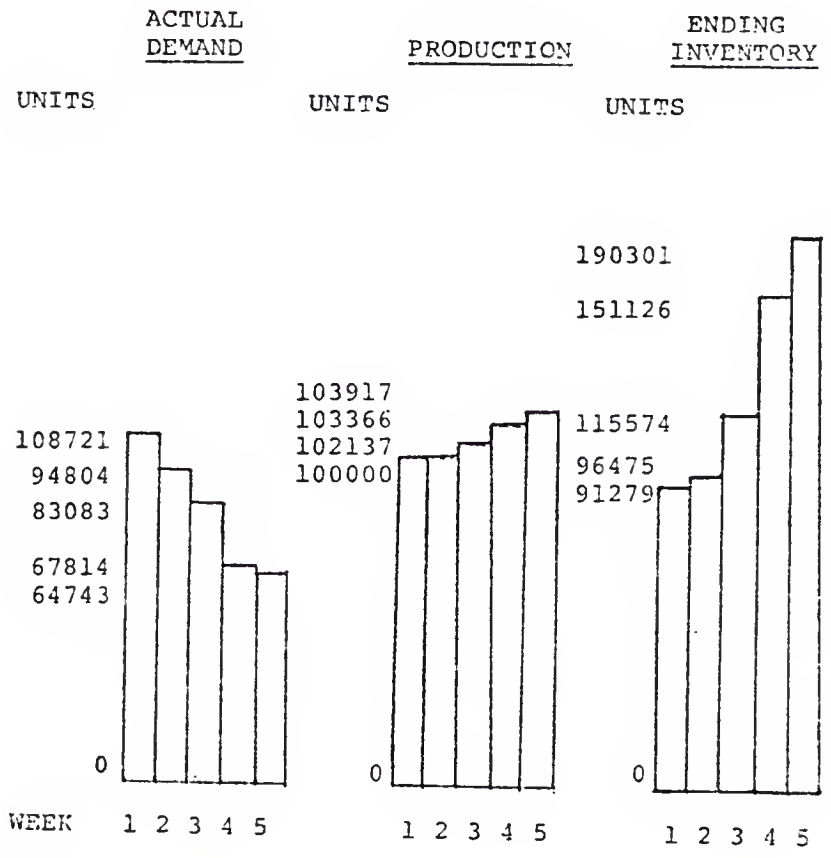
DEMAND FORECAST FOR NEXT FIVE WEEKS

WEEK	FORECAST DEMAND
6	60000
7	60000
8	60000
9	60000
10	60000

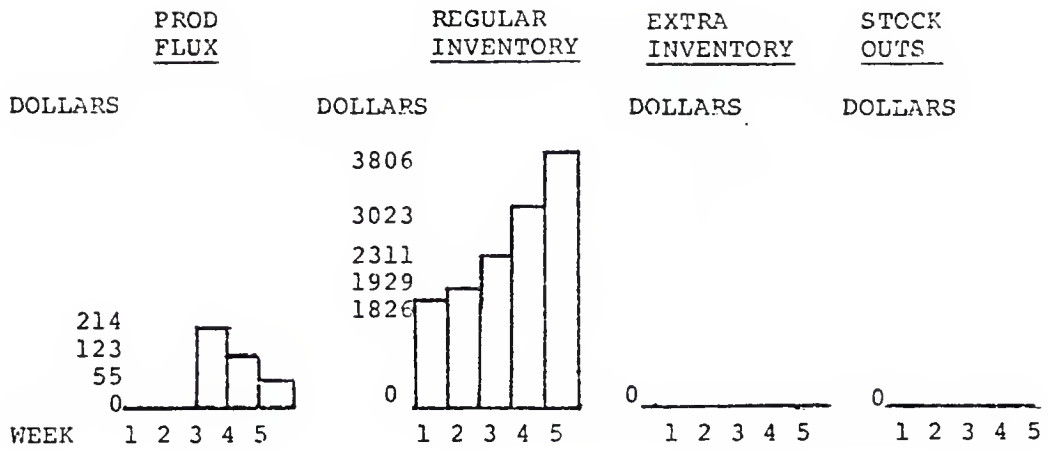
b. Report using graphical format and raw data level of summarization, for example:

OPERATING RESULTS
FOR WEEKS 1-5 MANAGER _____

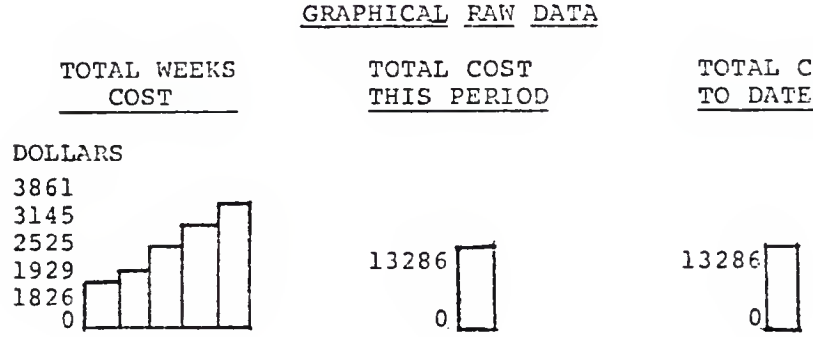
PRODUCTION UNITS



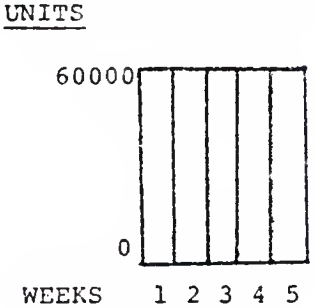
COSTS



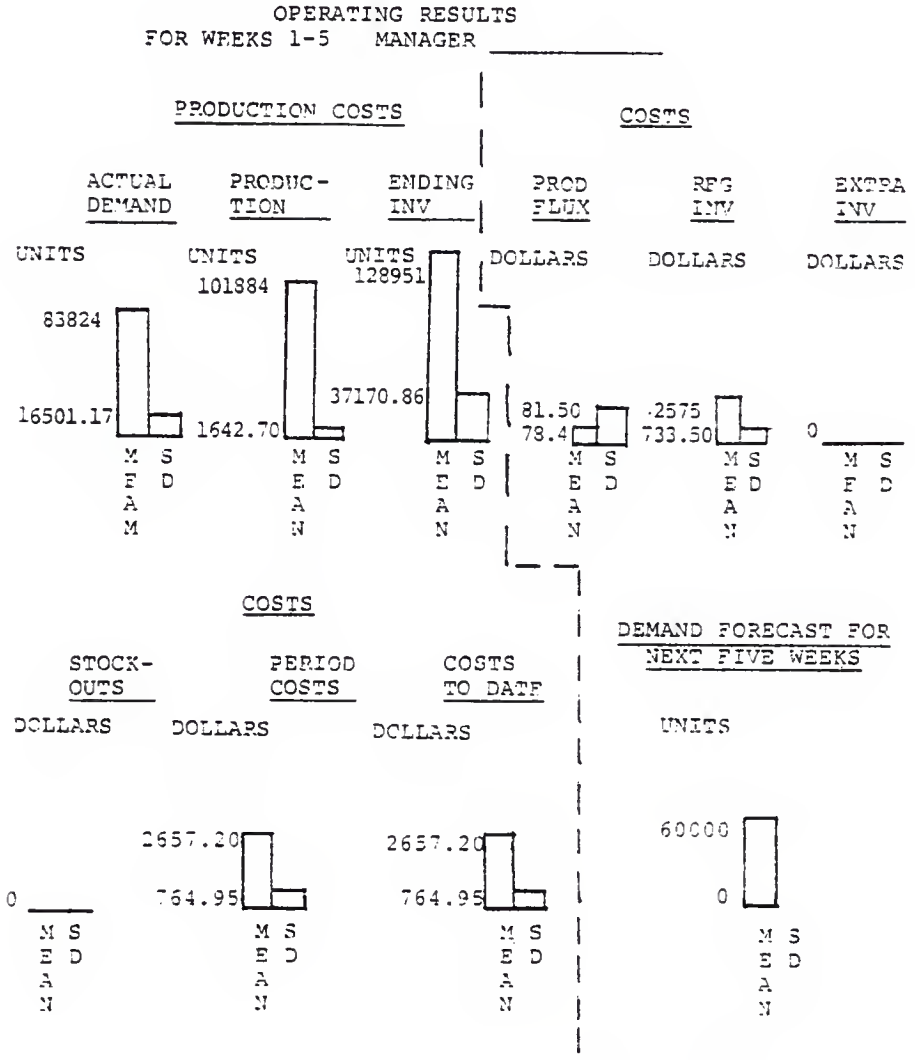
GRAPHICAL RAW DATA



DEMAND FORECAST FOR NEXT FIVE WEEKS



c. Report using graphical format and statistically summarized level of summarization, for example:



d. Report using tabular format and statistically summarized level of summarization, for example:

OPERATING RESULTS

FOR WEEKS 1-5 MANAGER_____

	ACTUAL DEMAND	PRODUCED	ENDING INV	PROD FLUX	REG INV
MEAN	83824	010884	128951	78.40	2579
STANDARD DEVIATION	16501.17	1642.70	37170.86	81.50	733.50

	STCK OUTS	PERIOD COST	COSTS TO DATE
MEAN	0	2657.2	2657.2
STANDARD DEVIATION	0	764.95	764.95

- -

DEMAND FORECAST FOR NEXT FIVE WEEKS

MEAN	60,000
STANDARD DEVIATION	0

e. Other. Please specify:_____

_____

_____

_____

_____

_____2. Which of the reports did you receive for use in completing the production task in the experiment?

a. Report using tabular format and raw data level of summarization

b. Report using graphical format and raw data level of summarization

c. Report using graphical format and statistically summarized level of summarization

d. Report using tabular format and statistically summarized level of summarization

3. All of the above production reports provided the following information for use in completing the task: actual demand, production, ending inventory, production flux, regular inventory, extra inventory, stock-outs, period costs, costs to date, and demand forecast for the next five weeks. What kind of additional information would you have found useful in completing the task?

_____

_____

_____

_____

_____4. To what degree were the goals of the production task clearly stated?

a. To a very small degree

b. To a small degree

c. To some degree

d. To a great degree

e. To a very great degree

_____5. To what degree were the problems experienced in completing the production task able to be solved using a variety of procedures?

a. To a very small degree

b. To a small degree

c. To some degree

d. To a great degree

e. To a very great degree

_____6. To what degree could the correctness of the decision that you made be verified in an actual organizational setting?

a. To a very small degree

b. To a small degree

c. To some degree

d. To a great degree

e. To a very great degree

_____7. To what degree was there more than one "correct solution" involved in the task?

a. To a very small degree

b. To a small degree

c. To some degree

d. To a great degree

e. To a very great degree

8. What is your business major?_____

9. Please indicate the total number of operations or production management courses that you have had at FSU or at any other college.

Undergraduate_____

Graduate_____

10. Have you previously performed a production task similar to the experimental task on-the-job?

_____If so, please specify._____

_____

_____

_____

_____

_____

_____

APPENDIX G

ASSIGNMENT TO TREATMENT GROUPS

ASSIGNMENT TO TREATMENT GROUPS

Subjects were randomly assigned to one of four treatment groups. The treatment was one of the four report types, i.e. TAB-RD, TAB-SSD, G-RD, G-SSD.

The random number generator RANF on the CDC CYBER 730 was used to generate uniformly distributed random numbers. The assignment was made on the following basis:

For each subject a random number, r, was generated and when $.00 \leq r \leq .25$ the subject was assigned to the TAB-RD treatment group.

When $.26 \leq r \leq .50$ the subject was assigned to the TAB-SSD treatment group.

When $.51 \leq r \leq .75$ the subject was assigned to the G-RD treatment group.

When $.76 \leq r \leq 1$ the subject was assigned to the G-SSD treatment group.

When a treatment group was full, i.e., there were six subjects assigned, then another random number was generated until an unfilled treatment group was found. Finally, when only one treatment group was unfilled, the remaining subjects were assigned to that group.

BIOGRAPHICAL SKETCH

Donald L. Davis was born July 25, 1933, in Pensacola, Florida. He graduated from Roosevelt High School, Honolulu, Hawaii, in June, 1951. He received a bachelor's degree with a major in mathematics and a minor in philosophy from The Florida State University in 1967, and a Master of Business Administration from the same institution in 1970. He was a member of the faculty of the College of Business at Florida State from 1969 to 1980. At present, he is a member of the faculty of the School of Business at Valdosta State College in Valdosta, Georgia.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philiosophy.

Richard A. Elnicki

Richard A. Elnicki, Chairman
Associate Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

R. W. Elliott /SBSN

Roger W. Elliott
Professor of Computer and
Information Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

H. Russell Fogler
Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William M. Fox
Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philiosophy.

Marvin E. Shaw
Professor of Psychology

This dissertation was submitted to the Graduate Faculty of the Department of Management in the College of Business Administration and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

March 1981

Dean, Graduate School